The living world

What is living

Unique features of living organisms
Growth,reproduction,ability to sense environment,respond,metabolism,ability to self replicate,self organise,interact and emergence to this list

Reproduction,likewise is a characteristic of living org.
For multicellular -> sexual
For fungi -> asexual spores
For yeast & hydra -> budding
For planeria -> true regeneration
Fragmentation-> fungi,filamentous alga,protonema of mosses
For unicellular org. Like amoeba growth and reproduction are synonymous
But there are some sterile org. Like mule,worker bees,infertile human,hence it also cannot be an all inclusive defining characteristic of living org.

Another characteristic of life is metabolism
An isolated metabolic reaction outside body in test tube is neither living nor non living. While metabolism is a defining feature of all living org. Without exception.
Isolated reactions are not living things but surely living reactions.
Hence cellular forms/ organisation of body is defining feature of life form
(AIPMT 2007)

All living organisms grow
Increase in mass and in no. Of individuals are twin characteristics of growth. Plants grow by cell division(multicellular) throughout their life. Unicellular org. Also grow by cell division
In animals growth is restricted upto an age. In majority of higher organisms growth and reproduction are mutually exclusive events. Growth has to be internally hence it's not a defining property.

Consciousness,a defining property of living organisms
(Organisms are distinguished unexpectedly)
Every living organisms respond & sense it's environment. (Plants respond to light,water,temp,pollutant,org.
And photoperiod affects reproduction in seasonal breeders,both plants & animals. And all animals handle chemicals entering them.)
Only human have self consciousness.
Coma patients are brain dead but body is responding (heart and lungs get replaced by machines

IMPORTANT POINTS
LIVING ORGANISMS ARE SELF REPLICATING, EVOLVING, SELF REGULATING INTERACTIVE SYSTEMS CAPABLE OF RESPONDING TO EXTERNAL STIMULI
ALL LIVING ORGANISMS (PAST PRESENT AND FUTURE) ARE LINKED TO ONE ANOTHER BY SHARING COMMON GENETIC MATERIAL BUT TO VARYING DEGREES
Property of tissues are not found in cells but present due to interaction among cells and similarly in organelle & molecules.

Diversity in the living world

Each different kind of plant,animal or organisms you see represents a species.
1.7-1.8 million species have been known and described which refers to biodiversity (no. & type of org. present on earth

Nomenclature

(To solve the possible dispute)
It is only possible when organism is described correctly(identification)
For plants -> ICBN (international code for botanical nomenclature) (AIPMT 2007)
For animals -> ICZN (international code for zoological nomenclature)

Binomial nomenclature by Carolus Linnaeus

Contains generic name and specific epithet
UNIVERSAL RULES:-
-> latinised (irrespective of origin), written in italics
-> first word in genus & next is species
-> when handwritten separately underlined & printed in italics which denote latin origin
-> genus starts with capital letter & species with small
Eg- *Mangifera indica linn* (NEET 2019)

Systematics

Branch of study including,
Different organisms,their diversity and relationship b/w them. Latin word *systema* means systematic arrangement of org.
Linnaeus used *systema naturae* as the title of his publication.
The scope of systematics was later enlarged to include identification,nomenclature and classification. Systematics takes into account evolutionary relationship b/w org.

Classification

Grouping into convenient categories based on easily observable characters.
We use convenient categories to study organisms & scientific term for these categories is taxa.
Animals,mammals,dogs represent taxa at different levels.
Based on characteristics all living organisms can be classified into different taxa which is called taxonomy

Modern taxonomic studies- external,internal structures,cell structure,developmental process,ecological info.

Processes that are basic to classification- Characterisation,identification,classification and nomenclature
Earlier classifications were based on the 'uses' of various org.

Taxonomic categories

Each step in classification represents a rank or category called taxonomic category and all of them makes taxonomic hierarchy. Each category is referred as unit of classification represents rank & is commonly termed as taxon.
Groups represent category(eg-insects) & it further denotes rank/taxon.
These groups/category are distinct biological entities and not merely morphological aggregates.

Species-
lowest category (AIPMT 2003)
Group of organism with fundamental similarities and can interbreed. Eg- indica,tuberosum,leo,sapiens
One genus may have 1 or more species representing different organisms,but having morphological similarities.
Eg- *P. tigris & P. leo , S. tuberosum & S. nigrum & S. melongena*

Genus-
Group of related species
Eg- *solanum* (potato & brinjal) , *panthera* (leo,pardus,tigris) , *felis* (cats)

Family-
Closely related genera with less no. Of similarity.
They are characterised on both vegetative & reproductive features of plant species.
Eg- *solanum,petunia,datura* are placed in solanaceae family, *panthera & felis* are placed in felidae family.
Canidae-> dog family

Order-
(Assemblage of families)
Order & higher taxonomic categories are identified based on aggregates of characters. Similar characters further decrease. Eg- convolvulaceae solanaceae are in order polymoniales based on floral characters,
Carnivora order include felidae and canidae

Class-
Eg- mammalia include order primata (monkey,gorilla,gibbon) & carnivora(tiger,cat,dog)

Phylum(division in plants)
Classes like pisces ,amphibia,reptilia,aves,mammalia are include in chordata phylum

Kingdom-
(Highest category)
Eg-plantae

IMPORTANT POINTS
Subcategories in this hierarchy in figure facilitate more sound & scientific placement of various taxa.
Higher the category greater is the difficulty of determining the relationship to other taxa at the same level.

TABLE 1.1 Organisms with their Taxonomic Categories

Common Name	Biological Name	Genus	Family	Order	Class	Phylum/ Division
Man	*Homo sapiens*	*Homo*	Hominidae	Primata (AIPMT 2011)	Mammalia	Chordata
Housefly	*Musca domestica*	*Musca*	Muscidae (NEET 2021)	Diptera	Insecta	Arthropoda
Mango	*Mangifera indica*	*Mangifera*	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae
Wheat	*Triticum aestivum*	*Triticum*	Poaceae	Poales	Monocotyledonae	Angiospermae

Taxonomical Aid-

Info gathered or actual specimen for primary source of taxonomic studies and training in systematics

Herbarium- (AIPMT 2013)
Collection of dried,pressed & preserved plant specimen & then the sheets are arranged acc. to classification.Info on herbarium sheet- date & place of collection, english local & botanical name,family,collectors name.
They serve as quick referral system in studies & become store house,repository for future use

Botanical garden-
Collection of living plants which are grown for identification. Each plant is labelled indicating botanical name & its family
Famous botanical gardens are at Kew (England), Indian Botanical garden, Howrah (India) and at National Research institute,lucknow (India)

Biological museum-
Set up in schools,colleges & include collection of preserved plant & animal specimens in jars in preservative solutions(formaline)
Insects are preserved in insect boxes after collecting,killing and pinning.
Larger animals are stuffed and preserved. They also contain collection of skeletons

Zoological parks-
(Wild animals under human care) by which we learn their food habits & behaviour. They are provided with condition similar to natural habitat

Photos are on next page

Key-
Used for identification of plants and animal based on affinity. They are based on contrasting characters generally in a pair called couplet. Results in acceptance of only one & rejection of other. Each statement in key is called a lead.Separate taxonomic keys are required for each taxonomic category such as family, genus and species for identification purposes. Keys are generally analytical in nature. (AIPMT 2013)

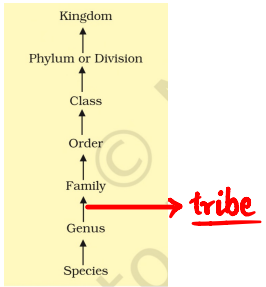


Figure 1.1 Taxonomic categories showing hierarchial arrangement in ascending order

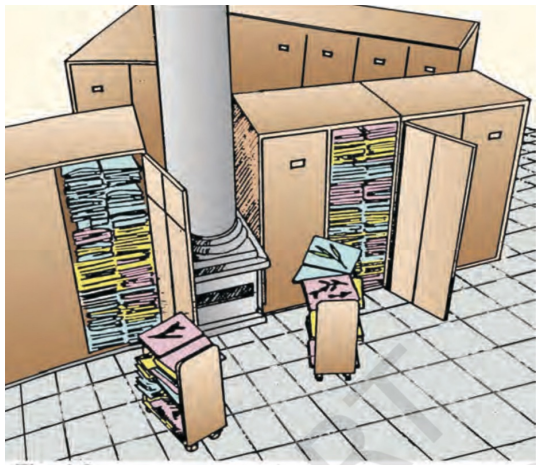


Figure 1.2 Herbarium showing stored specimens

Figure 1.3 Pictures showing animals in different zoological parks of India

Biological classification

The Early approaches

- Aristotle was first to give scientific classification by classifying plants into trees,herbs and shrubs (based on morphological characters)
- Linnaeus gave 2 kingdom classification i.e. plantae(bact.,BGA,Fungi, mosses,ferns,gymno.,angio.) & animals on basis of presence of cell wall
- Aristotle also classified animals in groups like enemia (having red blood) & anemia(the one not having)
- RH Whittaker in 1969 gave 5 kingdom classification i.e. MONERA,PROTISTA, FUNGI,PLANTAE,ANIMALIA

Issues in the early approaches

- It brought together prokaryotic bact. & blue green algae (BGA)
- Unicellular (eg-chlamydomonas) & multicellular (eg-spirogyra) were placed together
- Organisms with different cell wall were placed together
- No differentiation between mode of nutrition

Basis of 5 kingdom classification

=> cell structure
=> thallus organisation
=> mode of nutrition
=> reproduction
=>phylogenetic relationships

Table 2.1 Characteristics of the Five Kingdoms

Characters	Five Kingdoms				
	Monera	Protista	Fungi	Plantae	Animalia
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Noncellulosic (Polysaccharide + amino acid)	Present in some	Present with chitin	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multicellular/ loose tissue	Tissue/organ	Tissue/organ/ organ system
Mode of nutrition	Autotrophic (chemosynthetic and photosynthetic) and Heterotrophic (saprophytic/parasitic)	Autotrophic (Photosynthetic) and Heterotrophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic/ Saprophytic etc.)

If the genetic material of the bacteria is transferred through bacteriophages, the process is called Transduction (AIPMT 2002)

KINGDOM MONERA

(All bact.)

Introduction

They live in all type of habitat,even extreme. Bacterial structure is simple but complex in behaviour.
Some are autotrophic(chemosynthetic or photosynthetic) but majority are heterotrophic. ON BASIS OF SHAPE BACTERIA MAY BE:-
=> spherical - coccus
=> rod shaped - bacillus
=> comma shaped - vibrium
=> spiral - spirillum

Reproduction in bact.

Mainly by fission,in unfavourable cond. they produce spores. & also reproduce sexually by transfer of DNA From one cell to other(conjugation)

Phylum

Archaebacteria

(Primitive/ancient)
Live in most harsh habitat eg-HALOPHILES(salty areas),METHANOGENS(marshy areas),THERMOACIDOPHILES(hotsprings) (Odisha NEET 2019)
have well defined cell wall.
Methanogens found in most ruminant guts & produce biogas from animal dung (NEET-I and II-2016)

Eubacteria

Characterised by presence of rigid cell wall & if motile a flagella (AIPMT 2014)

In bacteria, plasmid is the extra chromosomal material (AIPMT 2002)

Mycoplasma

Lack cell wall & are smallest living cells and can live without O2 → aka PPLOs (Pleuro-pneumonia like organisms)
NEET 2017
AIPMT 2007

(AIPMT 2012)

Cynobacteria

Also called BGA & have chl-a & are photosynthetic autotrophs,unicellular,colonial,filamentous,marine or terrestrial habitat. Colonies are surrounded by gelatinous sheath.
& forms blooms in water bodies

N2 fixing bacteria

Fix atm. N2 in specialised cells called heterocysts, Eg-NOSTOC,ANABENA
Heterocyst provide anaerobic condition required for N2 fix.
(AIPMT 1994)

Chemosynthetic autotroph

Oxidise inorganic substances like nitrates,nitrites,ammonia & use released energy for ATP production
Play role in recycling N,P,Fe,S

Heterotrophs

Mostly imp decomposers,help in making curd,antibiotics,fixing N2 in legume roots & some are pathogens causing damage.
Eg of bacterial diseases-cholera,typhoid,tetanus,citrus canker

KINGDOM PROTISTA (NEET 2016)

All single cell eukaryotes,some have flagella or cilia & reproduces sexually & asexually involving zygote formation and cell fusion

Crysophytes

Diatoms/golden alga/desmids

Fresh water as well as marine water.float passively in water(plankton) Most are photosynthetic. In diatoms cell walls form two thin overlapping shells,which fit together in a soap box. Walls are embedded with silica & are indestructible thus they left behind large amt. of cell deposits in their habitat over billions of years & now called as DIATOMACEOUS EARTH (NEET 2016) Being gritty soil is used in polishing,filtration of oils & syrups.DIATOMS are chief producers of ocean.

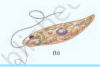
(AIPMT 2015)

Dinoflagellates

Mostly marine & photosynthetic. Appear yellow,green,brown,blue,red depending on pigments. Cell wall have stiff cellulose plates on outer surface. Most have 2 flagella(one longitudinal other transversely in furrow b/w plates. Red dinoflagellate (GONYAULAX) multiplies rapidly & cause red tide. Toxins released by them may kill fishes.

Euglenoids

Most are fresh water org. found in stagnant water. Instead of cell wall they have protein layer pellicle (makes body flexible). Have a short & a long flagella. They are photosynthetic in presence of sunlight & heterotrophs in absence of former by predating small org. They are connecting link between plants & animals. The pigments in them is identical to that of higher plants. Eg- EUGLENA



Slime moulds

Saprophytic protists. Body moves along decaying twigs & leaves engulfing organic material. Under suitable conditions they form aggregation called plasmodium (may grow over several feet) in unfav. cond. plasmodium differentiates & forms fruitning bodies bearing spores at their tips. Spores bear true walls,extremely resistant & survive for many years. Spores are dispersed by air currents.

Protozoans

All are heterotrophs & live as predators or parasites. 4 main groups:-

A) Amoeboid

Move & capture prey by psudopodia. Marine forms have silica shells on surface. Eg- amoeba,entamoeba (parasite)

B) Flagellated

Either free living or parasite. Have flagella. The parasitic forms causes disease like sleeping sickness. Eg- trypanosoma

C) Ciliated

Aquatic,actively moving,have thousands of cilia,have cavity (gullet) that opens to outside of cell surface. The coordinated movement of rows of cilia cause the water laden with food to be steered into the gullet. Eg- paramecium

D) Sporozoans

Have an infectious spore like stage in life cycle. Eg- plasmodium (Malarial parasite)

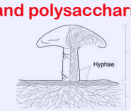
KINGDOM FUNGI

Heterotrophs,cosmopolitan (occur everywhere)

Introduction

STRUCTURE

They are filamentous except yeast which is unicellular. Body consists of long slender thread like Hyphae & it's network called mycelium. The continuous hyphae with multinuclear situation are called coenocytic & others have septae or cross walls. The cell wall contains chitin and polysaccharides (NEET-1-2016)



NUTRITION

Mostly heterotrophs & absorb soluble organic matter from dead substrate (saprophytes), some are parasites too. They can also live as symbionts in association with algae as lichens and with roots of higher plants like pinus as mycorrhiza

REPRODUCTION

=> By vegetative- fragmentation,fission,budding
=> Asexual- spores(conidia,sporangiospores, zoospores,aplanospores)
=> Sexual- oospore,ascospore,basidiospore
Spores are produced in fruitning bodies. The sexual cycle involves-

Plasmogamy —> karyogamy —> meiosis
Fusion of protoplasm b/w 2 motile or non motile gametes | Fusion of 2 nuclei | In zygote results in haploid spores

Haploid spores—> fusion begin—> dikaryophase—> nuclei fuse—> diploid body—> meiosis —> haploid spores

Four groups of fungi

Phycomycetes

Found in aquatic habitat & on decaying wood in moist & damp places or as obligate parasites on plants. Mycelium is asepetate/ coenocytic. Asexual repro. by zoospores (motile) or aplanospres (non motile). These are produces endogenously in sporangium. Zygospores are formed by fusion of two gametes,if similar -> isogamous or if dissimilar -> anisogamous or oogamous

Eg- mucor,rhizopus (bread mould) and albugo (parasitic fungi on mustard)

Mucor

Ascomycetes

(Sac fungi)

Multicellular (except yeast) Mycelium is branched & septate. The asexual spores are conidia produced exogenously on the special mycelium called conidiophores. Sexual spores are ascospores which are produced endogenously in sac like asci which are arranged in ascocarps (fruitning bodies). *Neurospora* is used in genetic & biochemical work. Many members like morels & truffles are edible & are considered delicacies. Eg- yeast,aspergillus,penicillium,claviceps,neurospora

Aspergillus

Basidiomycetes

(Mushrooms,bracket fungi,puff balls) (AIPMT 2007)

Grow in soil,logs,tree stamps,living plants as parasites Eg-rust & smut. Mycelium is branched & septate. Asexual spores are absent. Vegetative repro. by fragmentation. Sex organs are absent but plasmogamy takes place. Dikaryotic stage is found which gives rise to basidium. Karyogamy and meiosis takes place in basidium producting 4 basidiospores(exogenously). Fruitning body is called basidiocarp. Eg- Agaricus (mushroom),ustilago(smut),puccinia(rust) NEET 2018

AIPMT 2000

Agaricus

Hallucinogens are psychoactive compounds found in sp. of Amanita muscaria fungi AIPMT 2014

Deutromycetes

(Imperfect fungi)

Sexual phase is absent,they produce only asexual spores called conidia. Many members are decomposers & help in mineral cycling. (AIPMT 2015)

Eg- Colleotrichum ,trichoderma, alternaria

Alternaria

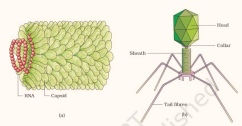
Viruses,viroids,prions & lichens

These acellular org. were not included in whittaker's classification

VIRUS

Introduction

They are not truly living & are acellular having inert crystalline structure outside living cell. Once they infect a cell they take over the machinery to replicate,killing the host. They are obligate parasites. NEET 2019



History of virus

The name virus meaning venom or poison was given by pasteur.

DJ Ivanowsky (1892) recognised certain microbes as caused organism of the mosaic disease of tobacco. These were found to be smaller than bacteria-proof filters. (AIPMT 2015)

MW Beijernick (1898) demonstrated that the extract of the infected plants of tobacco could cause infection in healthy plants called the fluid as (contagium vivum fluidum i.e. infectious living fluid) (AIPMT 2015)

WM Stanley (1935) showed that viruses could be crystallised and crystals consist largely of proteins.

Important points

In addition to proteins viruses also have genetic material that could either be RNA or DNA.

No virus contain both RNA & DNA. A Virus is a nucleoprotein and the genetic material is infectious (AIPMT 2014)

In general viruses that infect plants have ssRNA & Viruses infecting animals have either ssRNA or dsRNA or dsDNA.

Bacterial viruses or bacteriophage are usually dsDNA virus.

In plants symptom may be mosaic formation, leaf rolling & curling, yellowing & vein clearing,dwarfing & stunted growth

VIROIDS

Discovered by TO Diener in 1971. It was smaller than viruses and caused potato spindle tuber disease. It was found to be a free RNA ; it lacked the protein coat that is found in viruses,hence named viroid. The RNA of viroid was of low molecular weight (NEET-I-2016)

PRIONS

Only contains protein & lack DNA or RNA. Cause bovine spongiform encephalopathy (BSE) i.e. mad cow disease in cattle & also cause Cr-Jacob disease (CJD) in humans

LICHENS

Symbiotic association b/w algae & fungi.
ALGAE—> phycobiont(autotroph)
FUNGI—> mycobiont(heterotroph)
Lichens are good pollution indicators as they do not grow in polluted areas (sulphur indicator)

Plant Kingdom

IMPORTANT POINTS
Fungi,monerans,protists were earlier included in plant Kingdom but not now. BGA is not an algae anymore

Various Systems of classification
Earlier systems were based on gross morphology like habitat,colour,no. & shape of leaf

Artificial system
Based mainly on vegetative characters (easily affected) or on the androecium structure. Eg- Linnaeus classification of plants based on no. Of androecium. It had drawbacks like it separated closely related species,were based on few characters & equal weightage given to vegetative & sexual characters. AIPMT 2008

Natural system
Based on natural affinities among organisms & consider external,internal,ultra structure,anatomy,embryology,photochemistry. Eg- George Bentham & Joseph Dalton Hooker classification of flowering plants AI PMT 2007

Phylogenetic system
Most acceptable,based on evolutionary relationships,organisms belonging to Same taxa have common ancestor. AIPMT 2009

Different kinds of taxonomy

Numerical taxonomy
Based on observable characters using computers(no. & codes are assigned to each character) each character is given equal importance.

Cytotaxonomy
Based on chromosome no.,structure,behaviour

Chemotaxonomy
Chemical constituents of the plant to resolve confusions

ALGAE/THALLOPHYTA

Introduction
They are chlorophyll bearing simple thalloid,autotrophic & largely aquatic (both fresh&marine) org. Some algae form association with fungi(lichen), with animals(on sloth bear)

Economic importance
They fix 1/2 of the total CO2,They are primary producers & is energy source for aquatic animals Eg- PORPHYRA, LAMINARIA, SARGASSUM are used as food. Algin (brown algae) & carrageen (red algae) produce hydrocolloids(water holding subst.) Agar is produced from Geledium & gracilaria. Chlorella and spirullina are used as space food (SCP-Single cell protein)

Size & form
Chlamydomonas(microscopic unicellular),volvox(colonial),ulothrix & spirogyra(filamentous),kelps(massive marine form) NEET 2017

AIPMT 2000

Reproduction

Vegetative
By fragmentation. Each fragment develops into thallus

Asexual
By production of zoospores (motile)

Sexual
By fusion of 2 gametes

Table 3.1 Divisions of Algae and their Main Characteristics

Classes	Common Name	Major Pigments	Stored Food	Cell Wall	Flagellar Number and Position of Insertions	Habitat
Chlorophyceae	Green algae	Chlorophyll a, b	Starch	Cellulose	2-8, equal, apical	Fresh water, brackish water, salt water
Phaeophyceae	Brown algae	Chlorophyll a, c, fucoxanthin	Mannitol, laminarin	Cellulose and algin	2, unequal, lateral	Fresh water (rare) brackish water, salt water
Rhodophyceae	Red algae	Chlorophyll a, d, phycoerythrin	Floridean starch	Cellulose, pectin and poly sulphate esters	Absent	Fresh water (some), brackish water, salt water (most)

Isogamous
Gametes are similar in size
1) if motile-(flagellated) chlamydomonas (NEET 2014)
2) if nonmotile- spirogyra (non-flagellated)

Anisogamous
Gametes are different in size but of same capability to move
Eg- some species of chlamydomonas i.e. Udorina

NEET 2013

Oogamous
Female gamete is non motile but male is motile
Eg- volvox,fucus

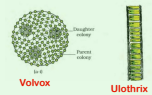
Types of algae

Chlorophyceae /green algae

Plant body is unicellular/colonial/ filamentous. Possess chl-a & b. Possess different shapes. Have stored food as starch or oil. Have pyrenoid(starch synthesis) body in chloroplast for storing protein. Inner cell wall —>cellulose & outer wall—>pectose. Vegetative rep.=> fragmentation,spores. Asexual =>by zoospores. Sexual=>isogamy,anisogamy,oogamy. Found in fresh,brackish,salty water. Have 2-8 equal & apical flagella

Eg- chlamydomonas,volvox,ulothrix,spirogyra,chara

AIPMT2012



reproduce vegetatively by fragmentation (AIPMT 2012)

chlorella is used as a food supplement (NEET 2020)

Phaeophyceae /brown algae

Branched,filamentous (ectocarpus). Have chl a,c,xanthophylls,caroteins. Have stored food as laminarin or mannitol. Have cellulosic cell wall. Have gelatinous covering of ALGIN. Plant parts are Holdfast,stipe,frond. Vegetative—> by fragmentation. Asexual—> by zoospores (heterokont) sexual—> by iso,aniso,oogamy. Gametes are pyriform (pear shaped) & bear a laterally placed flagella. Found rarely in fresh water,mostly in brackish & salt water. Have 2 unequal lateral flagella. Cellulose,pectin & polysulphate esters are found in cell wall.

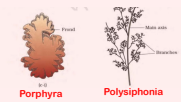
Eg- Ectocarpus,dictyota,laminaria,sargassum,fucus,kelps

Hydrocolloids are produced by red algae (carrageen) and brown algae (algin) (NEET 2016)

Rhodophyceae /red algae

They are multicellular. Have red pigment r-phycoerethrin. Found in warmer areas & occur in all light regions. Stored food is floridean starch which is similar to amylopectin & glycogen in structure. Vegetative—> frag. Asexual—> nonmotile spores Sexual—> oogamous by non motile spores. Found some in fresh & brackish water but most in salt water. Do not have any flagella.

Eg- polysiphonia,porphyra,glacilaria, geledium



BRYOPHYTES
(amphibians of plant Kingdom)

Introduction

Live in soil but dependent on water for sexual repro. Play important role in plant succession on bare rocks/soil. They also have thalloid like body but more differentiated than algae. Main members of bryophytes are mosses

Structure/plant body

It is thallus like,prostrate & erect. Have rhizoids in place of roots. Lack true root,stem,leaf but may possess structure like them. Main plant body is haploid (gamatophytic cause produces gametes)

Economic importance

Some mosses provide food for herbaceous mammals,birds,other animals. Species of sphagnum,a moss provide peat that have long been used as fuel, and because of their capacity to hold water used as packing material for transshipment of living material. Mosses with lichens are first to colonise rocks & hence are of great ecological importance. Act as Decomposers of rocks making suitable for growth of higher plants. Form green matts & prevents soil erosion.

Sex organs

Sex organs are multicellular and jacketed. Male sex organ—> anthridium(antherozoid) Female sex organ—> archaegonium(eggcell)

Fertilisation & development

Antherozoids(n) released in water come in contact with archaegonium/egg(n)—> zygote(2n)—>sporophyte(2n) —> spores(n)—> germination —> gametophyte(n)

LIVERWORTS

Plant body is thalloid & thallus is dorsiventral & closely appressed to substrate. Leafy members have tiny leaf in rows looking like stem. Perform ASEXUAL by fragmentation or gemmae formation & SEXUAL as sex organs are present on same or diff. thalli. Sporophyte is consist of foot + setae + capsule. Spores are produced within capsule. They have free living gametophyte & sporophyte is parasitised on it. Eg- marchantia,riccia

NEET 2013 Marchantia

MOSSES

Predominant stage is gametophyte. Consists of 2 stages—>protonema & leafy. Protonema develops from spore, creeping green,branched & frequently filamentous stage. Leafy develops from sec. protonema as a lateral bud,consist of spirally arranged leaves(this stage contains sex organs). Perform ASEXUAL by fragmentation & budding in sec. protonema or SEXUAL by antheridia,archaegonia. After fertilisation zygote develops into sporophyte. They have elaborate mechanism of spore dispersal.

Eg- funaria,sphagnum,polytrichum

PTERIDOPHYTES/ferns

compared to gametophytes of bryophytes, these have bigger gametophytes (AIPMT 2011)

Introduction

Includes horsetails & ferns. First to possess vascular tissue. Found in cool,damp,shady places though some may flourish in sandy soil condition.

Structure/plant body

Main plant body is sporophyte but also have free living gametophyte. Differentiation is seen in true root,stem & leaf. Leaves may be of 2 types:- microsporophylls(selaginella) or macrosporophylls(ferns) sporophyte bears sporangia that are subtended by leaf like appendages called sporophylls & sometime it may form compact structure called STROBILI or CONES or LAX
Eg- selaginella,equisetum

Sexual reproduction

Gametophyte bears antheridia & archaegonia. Water is required for transfer of male gamete to archaegonium. Antherozoid+egg—> zygote(2n) and it will further form sporophyte

Types of sporophyte

Homosporous-all spore of same kind. Eg- dryopteris,pteris,equisetum (majority)

Heterosporous-2 types of spores are produced(microspore & megaspore) Eg-selaginella and salvinia (AIPMT 2008)

Development of zygote into young embryo takes place within the female gametophyte (precursor to seed habit considered an important step in evolution) → AIPMT 2009, 2011

Life cycle

Meiosis in sporangia
↓
Spores (n)
↓
Germination
↓
Prothallus (Multicellular)
↓
Gametophyte (n)
↓
Male and female gamete (n)
↓
Fusion
↓
Zygote (2n)
↓
Sporophyte (2n)

Economic importance

Used for medicinal purposes and they also act as soil binders. They are also frequently grown as ornamentals.

Spilopsida
Psilotum

Lycopsida
Selaginella, Lycopodium

Sphenopsida
Equisetum

Pteropsida
Dryopteris, Pteris, Adiantum

they grow in marshy geographical locations due to need of water for fertilization (NEET2016, AIPMT2009)

GYMNOSPERMS (naked seeds) → NEET 2018

Ginkgo biloba is dioecious and a primitive gymnosperm NEET (2017)

NEET 2016

Ovules are exposed i.e. no ovary wall is present. Seeds are naked. They include medium trees,tall trees & shrubs. Giant redwood tree SEQUOIA is one of the tallest. Possess tap roots (pinus have mycorrhiza & cycas have coralloid roots i.e. associated with N2 fixing cyanobact.). Stems may be branched (pinus,cedrus) or unbranched (cycas) they have simple,compound leaf. Cycas have pinnate leaf that remain for few years & withstand temp. Humidity & wind. All conifers have needle like Leaves that reduces the surface area & reduce water loss. They are always heterosporous. The sporophylls may arranged spirally to form lax/strobili/cones. Strobili bearing microsporophyll/microsporangia is called microsporangiate/male strobili. Male & female cones on same tree —> Pinus , and male & female cone on different tree—> cycas

NEET 2016

The male and female gametophytes are not free living and are retained on sporophytes (NEET 2016)

ANGIOSPERMS

Smallest angiosperm—> wolfia , tallest angiosperm—> Eucalyptus. They provide food,fodder,fuel,medicines. Characteristic of dicots are tetramerous/pentamerous flower & that of monocot is trimerous flower. PEN (primary endosperm nucleus) develops into endosperm. Each embryo sac has 3 celled egg apparatus. Synergids and antipodals degenerate after fertilisation.

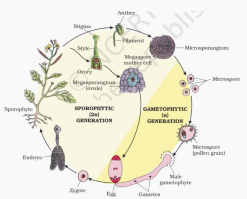


Figure 3.6 Life cycle of an angiosperm

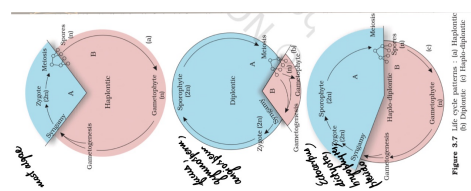


Figure 3.7 Life cycle patterns : (a) Haplontic (b) Diplontic (c) Haplo-diplontic

Animal Kingdom

Basis of classification

Levels of organisation
Cellular-sponges
Tissue level-coelenterates,ctenophore
Organ level-platyhelmenthis
Organ system-annelid...,adults of echinoderms

Symmetry
Asymmetric-sponges
Radially symm.-coelenterates,adult echinoderms,ctenophores
Bilateral symm.-annelid to chordate,larvae of echinoderm

Germ layer
Diploblastic-sponge,coelenterates,ctenophore
Triploblastic-platyhelmenthis,aschel...

Digestive system
Incomplete-platyhelmenthis,coelenterates
Complete-aschelmenthis to chordates

Circulatory system
Open-blood vessel -nt
Closed-blood vessel +nt

Coelom
Acoelomate-sponge,coelentera te,platyhelmenthis
Pseudocoelomate-aschelmenthis AIPMT 2010
Coelomate-annelids...

Notochord
It is mesodermally derived rod like formed on dorsal side during embryonic stage.
Chordates-animals with notochord in any stage of life
Eg-fish,amphibia,reptile,bird,mammal
Nonchordates-porifera to echinoderm.

Segmentation
Body is externally and internally divided into segments with serial repetition of at least some organ. Also called metameric segmentation or metamerism(phenomenon)
Eg-Earthworm(annelid), arthropods and chordates (AIPMT 2006, NEET 2021)

Classification of animals

Phylum PORIFERA
Habitat-They are generally marine,some fresh water.
multicellular
Canal system-water enter through ostia into central cavity (spongocoel) & goes out thr' osculum. Helpful in food gathering,respiratory exchange & waste removal. NEET 2021
Choanocytes/collar cells(flagellated)- line spongocoel NEET 2017
Digestion-intracellular
Skeleton-spicules & sponging fibres
Reproduction-hermaphrodite(bisexual),asexually by fragmentation.
Fertilisation-internal with indirect development(larval stage is found with morphologically dissimilar larvae)
Eg- sycon(scypha),spongilla(fresh water sponge),euspongia(bath sponge)

Phylum COELENTRATA (cnidaria)
Habitat-aquatic,mostly marine,sessile or free swimming
Cnidoblasts/cnidocytes-contain stinging capsules/nematocysts & present on tentacles & used for anchorage,defense,prey capturing NEET 2021
Body cavity-have central gastrovascular cavity with single opening(hypostome)
Digestion-both extra & intra-cellular
Skeleton-corals have calcium carbonate skeleton
Basic body forms-polyp(sessile & cylindrical form of hydra,adamsia) & medusa(umbrella-shaped & free swimming like Aurelia/jellyfish)
Eg-hydra,aurelia(jelly fish),obelia(sea fur),physalia(portugese man of war),adamsia(sea anemone),pennatula(sea pen),gorgonia(sea fan),meardrina(brain coral). NEET 2021
Alternation of generation(metagenesis)- AIPMT 2015 NEET 2021

Eg- obelia(sea fur) perform metagenesis

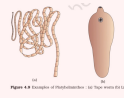
Phylum CTENOPHORA
Sea walnuts/comb jellies
Habitat-exclusively marine
Special organ-8 external rows of ciliated comb plates help in locomotion NEET 2021
Digestion-both extra & intra-cellular
Special property-bioluminescence(emits light)
Reproduction-only sexual (hermaphrodite)
Fertilisation-external with indirect development
Eg- pleurobrachia & ctenoplana

In hydra, nerve cells are present but brain is absent (AIPMT 2002)

Phylum PLATYHELMENTHIS

Flat worms

Body shape-dorsiventrally flattened, triploblastic, bilaterally sym & acelomate (NEET 2020)
Habitat-mostly endoparasites (in animals)
Special structure-hooks & suckers are found for support & absorption.
Some absorb nutrients directly from surface of host.
Excretory cells-flame cells help in osmoregulation
Reproduction-hermaphrodites
Fertilisation-internal with indirect development(many larval stages)
PLANERIA possess high regeneration capacity.
Eg- taenia(tape worm), Fasciola(liver fluke),planeria



Phylum ASCHELMENTHIS

Round worms

Body shape-circular cross section
Habitat-freeliving,aquatic,terrestrial ,parasite on plant & animal
Digestive system-complete with well developed muscular pharynx
Excretion-a tube removes waste through excretory pore
Reproduction-unisexual/ dioecious (also show sexual dimorphism~ male smaller than female)
Fertilisation-internal with direct or indirect development
Eg- ascaris (round worm),wucheria (filarial worm), ancyclostoma(hookworm)

NEET 2021

Phylum ANNELIDA

Body shape-marked out into metameres/segments (latin, annulus:little ring)
Habitat-aquatic, terrestrial, freeliving,rarely parasite
Locomotory organs-body wall has longitudinal & circular muscles.
Aquatic annelids like NEREIS possess lateral appendages, Parapodia for swimming.
Circulatory system-closed
Excretory system-nephridia help in osmoregulation.
Nervous system-paired ganglia connected by lateral nerves to a double ventral nerve cord.
Reproduction- some unisexual(NEREIS),some bisexual(EARTHWORM,LEECHES)
Eg- nereis,pheretima(earthworm), hirudinaria(blood sucking leech)

Phylum ARTHROPODA

Jointed appendages

Largest phylum(includes insects)
Segmentation-present
Skeleton-exoskeleton is of chitin
Body division-head,thorax,abdomen
Locomotion-by jointed appendages
Respiration-by gills,book gills,book lungs,tracheal system
Circulatory system-open
Sensory organs-antennae,compound & simple eye,statocysts/balance organs are found
Excretion-through malphigian tubules
Reproduction-dioecious
Fertilisation-usually internal(oviparous) with direct or indirect development
Eg-
Economically useful-apis(honeybee),bombyx(silkworm), Laccifer(lac insect)
Vectors-anopheles,culex,aedes(MOSQUITOES)
Gregarious pest-locusta(locust)
Living fossil-limulus(king crab)

Phylum MOLLUSCA

2nd largest phylum

Habitat-terrestrial or aquatic(marine/ freshwater)
Body division-covered by calcareous shell & is unsegmented with a distinct head,muscular foot,visceral hump
Special structure-soft & spongy layer of skin forms a mantle over the visceral hump
Respiration & excretion-space b/w hump & mantle (mantle cavity) have feather like gills which perform respiration & excretion
Sense organ-anterior head has sensory tentacles
Feeding organ-mouth have file like rasping organ called radula
Reproduction-usually dioecious & oviparous with indirect development
Eg-pila(apple snail),pinctada(pearl oyster),sepia(cuttle fish),loligo(squid),octopus(devil fish),aplysia(sea hare),dentalium(tusk shell),chaetuplura(chiton)

NEET 2021

Phylum ECHINODERMATA

Spiny bodied

Habitat-all marine
Endoskeleton-calcareous ossicles
Show retrogressive metamorphism(larvae is bilateral symmetrical but adult is radial)
Digestive system-complete with mouth on ventral/lower & anus on dorsal/upper side
Water vascular system-help in locomotion,capture & transport of food,respiration
Excretory system-absent
Reproduction-dioecious
Fertilisation-usually external with indirect development (free swimming larvae)
Eg- asterias(starfish),echinus(sea urchin),antedon(sea lily),cucumaria(sea cucumber) & ophiura(brittle star)

spiny bodied → AIPMT 2012

Larvae are bilaterally sym & adults are radial pentamerous symmetry. AIPMT 2004

Phylum HEMICHORDATA

Earlier was considered as a sub-phylum under chordata but now placed separately under nonchordata.
Habitat-worm like marine organisms
Body shape & division-body is cylindrical & contains anterior proboscis,a collar & a long trunk.
Proboscis gland is present.
Circulatory system-open
Respiration-by gills (Shared Ch. with chordates (NEET 2017)
Excretory organ-proboscis gland
Reproduction-dioecious animals
Fertilisation-external with indirect development
Eg- balanoglossus & saccoglossus

TABLE 4.1 Comparison of Chordates and Non-chordates

S.No.	Chordates	Non-chordates
1.	Notochord present.	Notochord absent.
2.	Central nervous system is dorsal, hollow and single.	Central nervous system is ventral, solid and double.
3.	Pharynx perforated by gill slits.	Gill slits are absent.
4.	Heart is ventral.	Heart is dorsal (if present).
5.	A post-anal part (tail) is present.	Post-anal tail is absent.

Phylum CHORDATA

Characteristic features:-
notochord,dorsal hollow nerve chord,paired pharyngeal gill slits,post anal tail,closed circulatory system
It is divided into 3 sub-phyla Urochordata/tunicata , cephalochordata and vertebrata

Protochordates

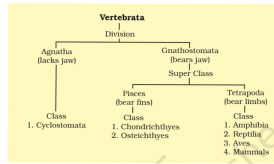
Urochordata
Exclusively marine,notochord present only in larval tail,Eg- ascidia,salpa, doliolum

Cephalochordata
Notochord extends from head to tail & is persistent throughout their life. Eg- branchiostoma(amphioxus or lancelet)

Vertebrata

→ poses notocord during embryonic period (NEET 2020)

The subphylum Vertebrata is further divided as follows:



"All vertebrates are chordates but all chordates are not vertebrates (NEET 2022)

→ agnatha

Class cyclostomata
Ectoparasites on fishes,6-15 pair of gill slits,cranium & vertebral column are cartilaginous(sucking circular mouth) ,they migrate to fresh water for spawning.
Eg- petromyzon(lamprey),myxine (hagfish)

All cyclostomes donot possess jaws and paired fins (NEET 2016)

Class chondrichthyes (cartilaginous fish)
NEET 2016
Cartilaginous endoskeleton,ventral mouth(notochord persistent throughout life),gill slits are separate without operculum,placoid scales are present(modification of teeth),lack air bladder,poikilothermous(cold blooded),male bear claspers,internal fertilisation,viviparous. Eg- electric organ present(torpedo),poison sting-trygon(sting ray),scolidon (dog fish),pristis(saw fish),carcharodon(great white shark)

= Pisces

Class osteichtyes (bony fish)
Mouth is terminal,4 pair of gill covered by operculum,cycloid/ctenoid scales are present,air bladder is present which regulates buoyancy,development is indirect. Eg- exocoetus(flying fish),hippocampus(sea horse), fresh water- labeo(rohu),catla(katla),clarias(magur) aquarium-betta(fighting fish),pterophyllum(angel fish)

→ tetrapods

Class amphibia
Cold blooded,body divided into head & trunk,have eyelids,have tympanum which represents ear,have common chamber cloaca for alimentary canal,urinary & reproductive tracts which open outsides,3-chambered heart. Eg- bufo(toad),rana(frog),hyla(tree frog),salamandra(salmander),ichthyophis(limbless amphibia)

Class reptilia
Cold blooded,skin is cornified & epidermal scaled or scutes are found,tympanum represents ear,3-chamber heart except crocodile,snakes & lizard shed their scales as skin cast, fertilisation is internal(direct development) Eg- chelone(turtle),testude(tortoise), chamelion(tree lizard),calotes(garden lizard),crocodilus(crocodile),alligator(alligator),hemidactylus(wall lizard),poisoning snakes- naja(cobra),bangarus(crait),viper a(viper)

NEET 2013

Class aves
feathers are found,forelimbs modified into wings,oil glands are present at the base of the tail,hindlimbs have scales,endoskeleton is bony(ossified) & long bones are hollow with air cavities (pneumatic),crop & gizzard are found,warm blooded organisms(homiothermous). Eg- corvus(crow),columba(pigeon), psittacula(parrot),struthio(ostrich),pavo(peacock),aptenodytes(penguin),neophron(vulture)

NEET 2022
NEET 2021

Class mammalia
Found in various habitat,mammary glands are found,skin possess hair,external ear in form of pinnae,different types of teeth are found,warm blooded. Eg- oviparous-> ornithorhynchus(platypus), viviparous-> macropus(kangaroo),pteropus(flying fox),camelus(camel),macaca(monkey),rattus(rat),canis(dog),felis(cat),elephas(elephant),eqqus(horse),delphinus(common dolphin),balaenoptera(blue whale),tiger,lion,pterous(bat)

NEET 2013

Figure 4.18 A jawless vertebrate - *Petromyzon*

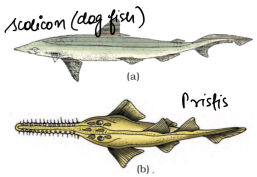


Figure 4.19 Example of Cartilaginous fishes : (a) *Scoliodon* (b) *Pristis*

Figure 4.20 Examples of Bony fishes : (a) *Hippocampus* (b) *Catla*

Figure 4.21 Examples of Amphibia : (a) *Salamandra* (b) *Rana*

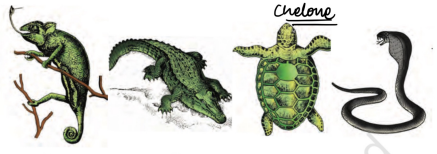


Figure 4.22 Reptiles: (a) *Chameleon* (b) *Crocodilus* (c) *Chelone* (d) *Naja*

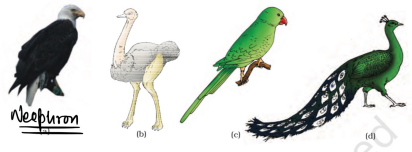


Figure 4.23 Some birds : (a) *Neophron* (b) *Struthio* (c) *Psittacula* (d) *Pavo*

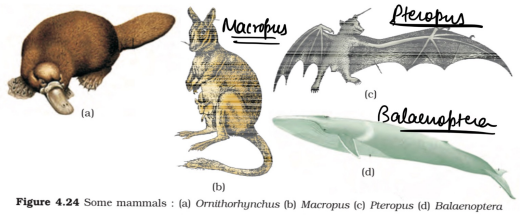


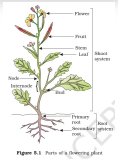
Figure 4.24 Some mammals : (a) *Ornithorhynchus* (b) *Macropus* (c) *Pteropus* (d) *Balaenoptera*

TABLE 4.2 Salient Features of Different Phyla in the Animal Kingdom

Phylum	Level of Organisation	Symmetry	Coelom	Segmentation	Digestive System	Circulatory System	Respiratory System	Distinctive Features
Porifera	Cellular	Various	Absent	Absent	Absent	Absent	Absent	Body with pores and canals in walls.
Coelenterata (Cnidaria)	Tissue	Radial	Absent	Absent	Incomplete	Absent	Absent	Cnidoblasts present.
Ctenophora	Tissue	Radial	Absent	Absent	Incomplete	Absent	Absent	Comb plates for locomotion.
Platyhelminthes	Organ & Organ-system	Bilateral	Absent	Absent	Incomplete	Absent	Absent	Flat body, suckers.
Aschelminthes	Organ-system	Bilateral	Pseudo coelomate	Absent	Complete	Absent	Absent	Often worm-shaped, elongated.
Annelida	Organ-system	Bilateral	Coelomate	Present	Complete	Present	Absent	Body segmentation like rings.
Arthropoda	Organ-system	Bilateral	Coelomate	Present	Complete	Present	Present	Exoskeleton of cuticle, jointed appendages.
Mollusca	Organ-system	Bilateral	Coelomate	Absent	Complete	Present	Present	External skeleton of shell usually present.
Echinodermata	Organ-system	Radial	Coelomate	Absent	Complete	Present	Present	Water vascular system, radial symmetry.
Hemichordata	Organ-system	Bilateral	Coelomate	Absent	Complete	Present	Present	Worm-like with proboscis, collar and trunk.
Chordata	Organ-system	Bilateral	Coelomate	Present	Complete	Present	Present	Notochord, dorsal hollow nerve cord, gill slits with limbs or fins.

Morphology of flowering plants

External visible structures of any organism. Which can be either vegetative or sexual in case of plants. Angiosperms are characterised by presence of root,stem,leaf,flower,fruit,modification



The root system

In dicots,direct elongate of radical leads to form primary root which bears lateral roots(sec. & tert.)

Types of root systems

Tap root system-primary root + it's branches Eg-mustard(dicot)
Fibrous root system-in monocots(wheat,rice) primary root is shortlived hence replaced by many several roots(arise from base of stem)
Adventitious root system-in banyan tree,grass,monstera root arises from other than radicle.

Functions of root

Absorb water&minerals,provides proper anchorage,storing reserve food,synthesis of plant growth regulators(auxin)

Regions of root

Root cap-protect,root apex(meristematic cells),helps in deep enchoring
Region for meristematic activity-cells divide without attaining maturity,reponsible for growth of root
Region of elongation-cells enlarge & increase length
Region of maturation-cells differentiate,epidermal cells convert into root hair that absorbs water & minerals

Modifications of root

Storage-tap roots of carrot & turnip,adven. Roots of sweet potato
Support-prop roots(vertically downwards) of banayan tree,stilt roots(oblique downwards from lower nodes of stem) of sugarcane & maize
Respiration-in some marshy plants develops vertically upward roots called pneumatophores. Eg-rhizophora AIPMT2000 NEET2022

The stem (shoot system)

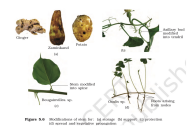
Ascending part of plant,bears node & intenode,bears bud(axillary or terminal),green in early stage & tough later

Modification of stem

Storage-eg-potato,ginger,turmeric,zaminkand,colocasia. Underground stems act as organs of perennation to tide over unfavourable cond.

eyes in potato tuber represents a node and its corresponding axillary buds. NEET 2014

Support-slendour & spirally coiled from axillary bud. Eg-{watermelon,pumpkin,cucumber}(gourds),grapevines



Defense(against plant eating animals)-axillary bud develops into thorns/spines in citrus & bougainvillea – NEET 2017 & NEET 2022

Photosynthesis-stem turns into flattened structure(opuntia) or fleshy cylindrical(euphorbia) which contain chlorophyll. eg Euphyllum and Casuarina NEET2016,2022

Vegetative propagation- RUNNER-underground stems of grass & strawberry spread to new niches & when older parts die new plants are formed. NEET 2022 STOLON-slender lateral branch arises from the base of the main axis & after growing aerially for some time arch downwards to touch the ground. OFFSET-a lateral branch with short internodes & each node bearing a rosette of leaves & tuft of roots. Eg-pistia & eicchornia(water hyacinth/terror of bengal). SUCKER-lateral branches originate from the basal and underground portion of the main stem,grow horizontally beneath the soil and then come out obliquely upward giving rise to leafy shoots. Eg-banana,pineapple,crysanthemum.

The leaf

Introduction

It is lateral,flattened structure which develops exogenously at node & bears a bud in axil(axillary bud) which later develops into branch. Leaves originate from shoot apical meristem & arranged in acropetal order

Parts of leaf

1)leaf base-leaf is attached to stem by leaf base & it may bear 2 stipules. In monocot leaf base expands into sheathing leaf base(cover stem partially or wholly) while in some legumes it may become swollen pulvinus leaf base.
2)petiole-holds leaf to stem,allow leaf to flutter in wind hence cooling leaf.
3)lamina/leaf blade-expanded green part with veins & veinlets with a midrib. Veins provide rigidity to blade & transport water,minerals & food material.

VENATION

arrangement of veins & veinlets.
Reticulate venation-veinlets form a network. Eg-dicots
Parallel venation-when the veins runs parallel to each other within a lamina. Eg-banana,monocot

Types of leaf

SIMPLE LEAF-lamina is entire or when incised,incisions do not touch midrib. Eg-peepal

COMPOUND LEAF-
When incisions reaches midrib breaking it into leaflets. Bud is not found in axil or leaflet

Pinnately compound-leaflets are present at rachis(represents midrib). Eg-neem

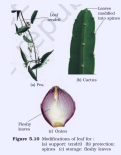
Palmately compound-leaflets are attached at common point i.e. tip of petiole. Eg-silk cotton

Phyllotaxy

Patter of leaves on branch/stem
ALTERNATE-one leaf at one node. Eg-china rose,mustard,sunflower
OPPOSITE-a pair of leaf at one node. Eg-calotropis,guava
WHORLED-more than 2 leaves from one node. Eg-alstonia NEET 2013

Modification

Support-tendrils of peas
Defense-spines of cacti
Storage-fleshy leaves of onion & garlic
Photosynthesis-(phyllode) petioles expand & become green cause leaves are short lived. Eg-Australian acacia
Insectivory-pitcher plant,venus fly trap



The inflorescence

The arrangement of flowers on the floral axis
A flower is a modified shoot(shoot apical meristem changes to floral meristem, internode do not elongate & the axis get condensed.
The apex produces different kinds of floral appendages laterally at successive nodes instead of leaf. When shoot tip transforms into flower it is always solitary.

Racemose inflorescence

1) the main axis continues to grow and does not terminate.
2) flowers are arranged in acropetal order.
3) main axis is monopodial.
4) Eg- fabeaceae family

Soyabean, Kankchan NEET 2013

Cymose inflorescence

1) the main axis terminate in a flower. → Neet 2013
2) flowers are arranged in basipetal order.
3) main axis is sympodial.
4) Eg-potato,liliaceae

The Flower

Introduction

It is reproductive unit. A typical flower has 4 whorls on swollen end of the stalk/pedicel called thalamus which are calyx,corolla,androecium,gynoecium. Calyx & corolla are accessory while other too are reproductive.
PERIANTH-in lily the calyx & corolla are not distinct or differentiated and are termed as perianth

Parts of flower

1)calyx-green,protect flower in bud stage,photosynthetic,outermost whorl. Gamosepalous(sepals united),polysepalous(sepals free)
2)corolla-to attract insects,may be tubular,bell shaped,funnel-shaped,wheel shaped. Gamopetalous(fused corolla),polypetalous(free petals)
3)Androecium/stamen(stalk+filament+anther)-anther->bilobed,each lobe having 2 pollen sacs. Sterile stamen is staminode. Stamens attached to petals->epipetalous eg-brinjal. Stamens attached to sepals->epiphyllous eg-lily
Polyandrous-free stamen. Monoadelphous-stamens in 1 bundle(china rose). Diadelphous-in 2 bundles (pea).
Polyadelphous-in more than 2 bundles(citrus)
There may be variation in length of filaments

Neet 21,22

NEET 2016

4)gynoecium/carpel/pistil(stigma+style+ ovary)-ovary us enlarged basal part,stigma is receptive surface.each ovary bears one or more ovules attached to flattened cushion like placenta & One ovule have one embryo sac.
Monocarpellary-one carpel in flower. Multicarpellary-more than 1 carpel in a flower. Apocarpous-free carpel(lotus, rose). Syncarpous-fused carpel(mustard, tomato)

Types of flowers

On basis of symmetry

Actinomorphic(radial)-mustard,datura,chilli NEET'16

Zygomorphic(bilateral)-pea,Gulmohar,bean,cassia

Asymmetric-canna AIPMT 2011

On basis of floral appendages

Trimerous-floral appendages in multiple of 3

Tetramerous-multiple of 4

Pentamerous-multiple of 5

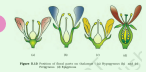
On basis of position of ovary

Hypogynous(superior ovary)-mustard,china rose,brinjal,mango,coconut NEET 2015

Perigynous(half inferior)-ovary in centre & other at rim of thalamus. Eg-plum,peach,rose NEET 2020, AIPMT 2011

Epigynous(inferior)-ovary enclosed in thalamus. Eg-guava,cucumber,ray florets of sunflower

NEET 2020



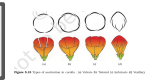
On basis of presence of bract

Bracteate-flowers with bract

ebracteate-flowers without bract

Aestivation

The mode of arrangement of sepals or petals in floral bud with respect to the other members of the same whorl



Valvate

Sepals/petals in a whorl just touch one another at margin without overlapping. Eg-calotropis

Twisted

One margin of appendage overlaps that of next one. Eg-china rose,lady finger,cotton

Imbricate

Margins of appendage overlap one another in any direction. Eg-cassia,gulmohur

NEET 2014

Vaxillary

Largest petal(standard) overlaps 2 lateral(wings) which in turn overlaps 2 smallest(keels). Eg-pea,bean. It is also called papilonaecious

NEET'15, 16

Placentation

Arrangement of ovules within ovary

Marginal

Placenta forms ridge along ventral suture of ovary & ovule are formed on it forming 2 rows Eg-pea

Axile

Placenta is axial, ovules attached to multilocular ovary Eg-china rose,tomato, lemon

NEET 2010, 2012

Parietal

Ovules develop on inner wall of ovary or periphery. Ovary becomes 2 chambered cause of false septum. Eg-Mustard, argemone

NEET 2019

Free central

Ovules are born on central axis & septum are absent. Eg-dianthus,primrose

NEET 2016

Basal

Placenta develops from base of ovary & single ovule is attached. Eg-sunflower,marigold

AIPMT 2010

Fruit (matured ovary) = pericarp(wall) + seed

After fertilisation ovary—> fruit, ovule—>seed. If pericarp is thick & fleshy it gets differentiated into epi,meso,endo -carps. Mango and coconut are drupe fruits cause developed from monocarpellary superior ovary. In mango mesocarp is edible & in coconut mesocarp is fibrous but in both endocarp is stony

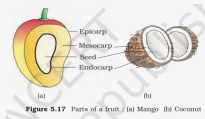
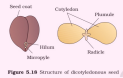


Figure 5.17 Parts of a fruit : (a) Mango (b) Coconut

Seed = seed coat + embryo(radicle+axis+cotyledon)

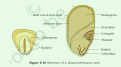
Dicot seed

Hilum is a scar on seed coat through which developing seed was attached to fruit.
Above hilum there is small pore (micropyle) → NEET 2020
& cotyledons reserve food and are fleshy.
Endospermic seeds- castor
Non-endospermic seeds-bean,pea,gram, groundnut



Monocot seed

They are generally endospermous but orchid is not.
Seed coat is membranous & fuse with fruit wall.
Endosperm is bulky & its outer covering is proteinaceous called aleurone layer. Embryo is found in a groove at one end of endosperm. It's cotyledon is shield shaped & called scutellum.
Plumule & radical enclosed in sheaths called coleoptile & coleorrhiza

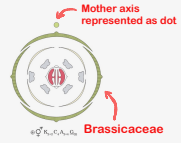


Semitechnical descriptions of a typical flowering plant

Br —> bractate
K —> calyx
C —> corolla
P —> perianth
A —> androecium

G —> gynoecium
$\underline{G}$ —> superior ovary
$\overline{G}$ —> inferior ovary
♂ —> male
♀ —> female
⚥ —> bisexual

⊕ —> actinomorphic
% —> zygomorphic

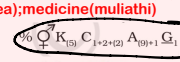


Floral formula shows cohesion & adhesion b/w whorls

Description of some important families

FABEACEAE

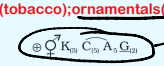
Earlier called papilionoideae, a sub family of leguminosae & is distributed all over world.
Vegetative character-trees,herbs,shrubs,roots with nodules. STEM-erect/climber. LEAVES-alternate,pinnately comp. or simple,pulvinate base,stipulate,reticulate venation.
Floral character-racemose,bisexual,zygomorphic. CALYX-5 gamosepalous(valvate/imbricate aestivation). COROLLA-5,polypetalous;papilonaceous,keel enclosing. AIPMT 2012
ANDROECIUM-10,diadelphous(9+1), AIPMT 2010 dithecous anther. GYNOECIUM-superior,monocarpellary,unilocular with many ovules,single style. FRUIT-legume;seed:one to many,non endospermic.
Economic importance-sources of pulses(gram,arhar,sem, moong,soyabean),edible oil(soyabean,groundnut);dye(indigofera);fibres(sunhemp);fodder(sesbania,trifolium);ornamentals(lupin,sweet pea);medicine(muliathi)



AIPMT 2010

SOLANACEAE

Also called potato family,distributed in tropics,subtropics,& event temperate zones.
Vegetative characters-mostly herbs,shrubs,rarely small trees. STEM-herbaceous,rarely woody,aerial;erect,cylindrical branched,solid/hollow,hairy or glabrous,underground in solanum tuberosum. LEAVES-alternate,simple,rarely pinnately comp.,exstipulate,reticulate.
Floral characters- INFLORESCENCE-solitary,axillary,cymose in solanum. FLOWER-actinomorphic,bisexual. CALYX-5(united sepals),valvate,persistant. COROLLA-5(united & valvate). ANDROECIUM-5(epipetalous). GYNOECIUM-bicarpellary,obligately placed,syncarpus,superior,bilocular,placenta swollen with many ovules,axile placentation. FRUIT-berry,capsule. SEEDS-many,endospermous
Economic importance-food(tomato,brinjal,potato),spice(chilli), medicine(belladona,ashwagandha);fumigatory(tobacco);ornamentals(petunia). NEET 15

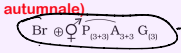


NEET 2015

AIPMT 2001

LILIACEAE

Also called lily family,representative of monocots,distributed world wide.
Vegetative characters-perennial herbs with underground bulb/corms/rhizomes. LEAVES-mostly basal,alternate,linear,exstipulate,parallel venation. Floral characters- INFLORESCENCE-solitary/cymose;often umbellate clusters. FLOWER-bisexual,actinomorphic. PERIANTH-tepal six(3+3){often united into tube},valvate. ANDROECIUM-6,3+3, epitepalous. GYNOECIUM-tricarpellary,syncarpous, NEET 2016 superior,trilocular with many ovules;axile placentation. FRUIT-capsule,rarely berry. SEED-endospermous.
Economic importance-good ornamentals(tulip,gloriosa), medicine(aloe),vegetables (asparagus), colchicine(colchicum autumnale)



AIPMT 2010

Anatomy of flowering plants

Tissues
Group of cells having common origin & usually perform common function

Meristematic tissue
Actively dividing cells, growth is restricted to meristems areas

Primary meristem

Apical meristem
Present at root/shoot apex, & shoot apical meristem left behind constitute axillary bud

Intercalary meristem
Occur b/w mature tissues & occur in grasses & regenerate parts removed by grazing animals. NEET 2019

Sec. meristem or cylindrical meristem

Lateral meristem
Occur in parts which produce woody axis,appear later & mature regions of shoots/ roots. Eg-fascicular vascular cambium,interfascicular cambium,cork cambium

Newly formed cells → Specialisation → Mature/ Permanent cells

During primary growth,specific regions of apical meristems produce dermal tissue,ground tissue & vascular tissue which are permanent.

responsible for ↑ in girth
NEET 2015

Permanent tissue
Lost ability to divide

Simple tissue
Made of single type of cells

Parenchyma
Isodiametric(spherical,oval,round ,polygonal,elongated),thin cell wall of cellulose,small intercellular space,performs photosynthesis,storage,secretion

Collenchyma
Found in layers or patches below epidermis in most dicots,thickened at corners,thick cell wall(pectin+hemicellulose),{oval, spherical & polygonal},no intercellular space,chloroplast present,provides mech. Support to young stem & growing parts.

It has been observed in Sterculia capsule
AIPMT 2003

Schlerenchyma
Long narrow cells,lignified cell wall with pits,dead cells without protoplast,mech. Support

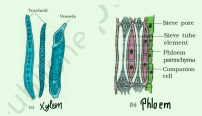
Fibres
Thick walled, elongated/ pointed cells in form of groups

Sclerids
Spherical,oval, thickened, dead cells,narrow cavity called lumen is present. Found in fruit walls,pulp of fruits like guava,pear, sapota

Complex tissue
Made of many types of cells

XYLEM
Conducts water & min. & gives mech. strength.
Tracheids-elongated, tubelike,lignified, dead cells,tapering ends, without protoplast
Vessels-long cylindrical tube like struc.,made of many vessel members connected via perforations, lignified walls,large central cavity,dead cells.
Their presence marks plant as angiosperm & gymno. do not have it
Fibres-obliterated central lumen,maybe septate or aseptate
Parenchyma-living,thin walled,{store starch,fat,tannins}. The radial conduction of water takes place by ray parenchymatous cells.
Primary xylem is of 2 types-
PROTOXYLEM-first formed
METAXYLEM-later formed
Endarch-protoxylem is towards pith & metaxylem towards periphery. Eg-stem
Exarch-opposite. Eg-roots

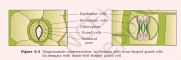
PHLOEM
Transports food. Gymnosperms lacks sieve tube nut have sieve cells & albuminous cells in place of companion cells
Sieve tube elements-long,longitudinally arranged;perforated end walls(sieve plates),mature sieve element possess peripheral cytoplasm,large vacuole but lacks nucleus.
Companion cells-specialised parenchymatous cells. Sieve tube elements & these are connected via pit fields & help in maintaining pressure gradient in sieve tubes.
Parenchyma-long,tapering cylindrical cells,dense cytoplasm & nucleus,have pits for plasmodesmata,stores food & resins,latex,mucilage. It is absent in most monocots.
Fibres/bast fibres-generally absent in primary phloem,have pointed needle like apices,thick cell wall & at maturity they loose protoplast. Phloem fibres of jute,flax & hemp are commercially used.
PROTOPHLOEM-first formed,narrow sieve tube
METAPHLOEM-later formed,bigger sieve tube



gymnosperms have albuminous cells and Seive cells. They lack Sieve tubes and companion cells (NEET 2019)

THE TISSUE SYSTEM (Based on location)

Epidermal T.S.
*forms outer covering.
*comprises cells+stomata+epidermal appendages(trichome/hair)
*epidermis is usually single layered(elongated,compactly placed parenchymatous cells.
*cuticle(wax) prevents transpiration.
*guard cells of monocot-> dumbell
*guard cells have outer wall thin & inner wall thick. & sometimes epidermal cells form subsidiary cells.
{stomatal apparatus=aperture+guardcell+subsidiary cell} NEET 2016
*root hairs are unicellular elongations,on stem epidermal hairs are called trichome[usually multicellular(branched/ unbranched) & may be secretory & prevents water loss]



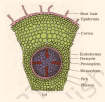
Ground T.S.
*constitute all tissues except epidermis & vascular bundles. Eg-parenchyma,collenc.,schle. AIPMT2017
Parenchyma cells are present in cortex,pericycle, pith & medullary rays in primary stem & roots.
*in leaves ground tissue consist of thin walled chloroplast containing cells & is called mesophyll

Vascular T.S.
*Consist of xylem & phloem in dicot,cambium is found in b/w vascular bundles & form sec. phloem & xylem (open vascular bundles)
*in monocot they are closed
*if xylem & phloem are arranged in alternate manner in diff. Radii it is called radial (as in roots).
*conjoint-> X & P are alng same radii. (Common in stem & leaves)
*conjoint vascular bundles usually have phloem located outside/periphery of xylem

Anatomy of Dicot & Monocot plants

DICOT ROOT

Outer -> epiblema(unicellular root hairs) & then parenchymatous cortex(inner layer is endodermis comprising barrel shaped cells without intercellular space with casparian strips(suberin) . Next is pericycle from which several roots& vascular camb.(sec. growth) starts. Pith is small/ inconspicuous & parenchyma b/w vasc. Bundles are called conjuctive tissue. Usually 2-4 xylem & phloem patches are found. Cambium ring develops from b/w xylem & phloem. All inner to endodermis(pith+pericycle+vasc. Bundles) constitutes STELE!



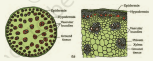
MONOCOT ROOT

It is similar to dicot root but have more than 6 polyarch xylem bundles & pith is large and well developed.

MONOCOT STEM

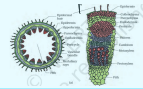
Has schlerenchymatous hypodermis,scattered vasc. Bundles(each surrounded by schlerenchymatous bundle sheath & large parenchyma ground tissue) , vascular bundle are conjoint ,closed with peripheral bundles are smaller than central. Phloem parenchyma is absent & water containing cavity are present within the vascular bundles

NEET 2018



DICOT STEM

Epidermis(cuticle+trichome+stomata), then cortex = cells b/w epidermis & pericycle and consist of 3 sub-zones -> hypodermis(collenchyma),cortical layers(parenchyma),endodermis(rich in starch grain hence called starch sheath).
Pericycle -> inner to endodermis & above phloem in form of semilunar patches of schlerenchyma.
B/w vasc. Bundles -> few layers of radially placed parenchyma constitute medullary rays.
Large no. of vasc. bundles are arranged in a ring with conjoint open & endarch]-> characteristic of dicot stem.
Rounded parenchyma with large spaces constitute pith.



DICOT LEAF

(Dorsiventral)

Cosist of epidermis(covers both adaxial/upper surface & abaxial/ lower surface) + mesophyll + vascular system. Veins vary in thickness cause of reticulate venation. Abaxial have more stomata than adaxial. Tissue b/w both epidermis is called mesophyll.

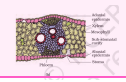
Mesophyll → Palisade parenchyma (Closer to adaxial surface)
Mesophyll → Spongy parenchyma (Closer to abaxial surface)

Vascular system ->seen in veins & midrib(size of bundles depend on size of veins.
Vascular bundles are surrounded by thick walled bundle sheath cells.

MONOCOT LEAF

(Isobilateral)

Similar to dicot but stomata on boths side are same; mesophyll are not differentiated in 2 types.
In grasses, some adaxial epidermal cells along the veins get modified into large,empty,colourless bulliform cells which gets turgid to make leaf surface exposed & become flaccid (leaf curl) to minimise H_2O loss. Parallel venation means same size veins,same size vascular bundle...except in main veins seen in vertical section of leaf



Secondary growth (Increase in girth)

Tissues involved (lateral meristem) are vascular cambium and cork cambium

Vascular cambium

Meristematic layer which cuts off vascular tissue

Formation of cambial ring

Cambium b/w vasc. bundle(intrafascicular cambium) and cells of medullary rays become meristematic & form interfascicular cambium & in total continuous cambial ring is formed.

Activity of cambial ring

It cut off new cells(sec. xylem towards pith,sec. phloem towards periphery). Cambium is more active on inner side than outer hence amt. of sec. xylem is more than sec. phloem. Hence soon form compact mass. Primary & sec. phloem get crushed due to continued formation & accumulation of sec. xylem. However primary xylem remains more or less intact in or around centre. At some places cambium forms narrow band of parenchyma (passes thr' sec. xylem & sec. phloem in radial direction which is called sec. medullary rays.

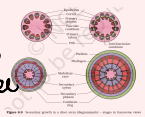
SPRING/EARLY WOOD-produced during spring,cambium is more active,produces more xylary element with vessels(large cavities),light in colour with low density.
AUTUMN/LATE WOOD-produced during autumn,cambium is less active,produce less xylary element with narrow vessels,darker in colour with high density.
HEARTWOOD-Comprises dead elements with high lignified walls(give mech. Strength to stem from centre)
SAPWOOD-comprises conducting tissue (periphery of sec. xylem),lighter in colour,H_2O & mineral transport.

Neet 2020

In older trees,greater part of sec. xylem is dark brown due to deposition of tannin,resin,oil,gum,aromatics,essential oils in central(innermost stem)

annual rings in a cut stem provides an estimate of age of tree

NEET2013



Cork cambium

Due to vasc. cambium,cortex & epidermis get broken & need to be replaced (new protective layers). Hence cork cambium/phellogen develops from cortex(a meristem) & cuts cells in outer cork/phellem & inner in sec. cortex (phelloderm).
Cork has suberin deposition (impervious);sec. cortex is parenchymatous. Phellem,phellogen & phelloderm are collectively known as periderm. Cork cambium builds pressure upon the remaining layers peripheral to phellogen which die & slough off. Bark is a non technical term used for all exterior to vascular cambium i.e. periderm with sec. phloem.

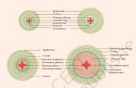
EARLY/SOFT BARK- formed early in season
LATE/HARD BARK- formed at end of season

At certain regions, phellogen cuts off closely arranged parenchyma cells which soon rupture epidermis,forming lens shaped openings called lenticles(gaseous exchange & occur in most woody trees)

AIPMT (2013)

Sec. growth in roots

In dicot root,vascular cambium is completely sec. in origin (originates from tissue located just below the phloem bundles,a portion of pericycle tissue ,above the protoxylem forming a complete & continuous many ring,which later becomes circular.
Further events are similar as above.



"{{Sec. growth also occurs in gymnosperms but does not occurs in monocotyledons.}}"

o
n

Structural organisation in animals

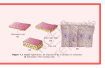
A group of similar cells along with intercellular subst. performing specific function is known as TISSUE. when 2 or more organs perform a common function by the physical or chemical interaction,they together form organ system.

Animal Tissue

Epithelial tissue

It has a free surface which faces body fluid or outside environment hence forms covering. Cells are compactly packed with little intercellular space.

Simple
Single layer,lining for body cavities,ducts & tubes



- **Squamous**: Flattened cells with irregular boundaries form diffusion boundaries. Eg- wall of blood vessels,air sac of lungs.
- **Cuboidal**: Cube like cells perform secretion & absorption. Eg- ducts of glands, tubular part of nephron
- **Columnar**: Tall,slender cells with nuclei at base help in secretion & absorption. Eg- Lining of stomach,intestine

Compound
2 or more layers of cell, protective function in skin. Cover dry surface of skin ,moist surface of buccal cavity,pharynx,inner lining of salivary glands & pancreatic ducts.

Brush border like cuboidal cell are present in PCT.

Ciliated epithelium
May be cuboidal/columnar,transportation. Present inside hollow organs like bronchioles,fallopian duct.

Glandular epithelium
May be UNICELLULAR-isolated glandular cell(eg-goblet cell) OR MULTICELLULAR-cluster of cells (eg-salivary gland)

found in alimentary canal (NEET '20)

May be EXOCRINE-have duct(eg-mucus,saliva ear wax,oil,milk) OR ENDOCRINE-ductless(eg-thyroid)

Junctions

- **Tight junction**: To stop substance to leak
- **Adhering junction**: Keeps neighbouring cells together
- **Gap junction**: For communication:- —> transfer of ion —> small molecules —> sometime big molecules
- **Connexis**: With the help of 2 protein cylinders

Neet 2015

Connective tissue
(Most abundant in body)

All cells in them(except in blood) secrete fibres of structural protein collagen & elastin. the fibres give strength,stretchability,elasticity. Cells also secrete polysaccharide (modified) which accumulate b/w cells and form matrix(ground substance).

Loose connective tissue
Fibres loosely arranged in semi-fluid matrix

- **Areolar**: Beneath skin,contain fibroblast(secrete fibre),macrophages, mast cells. Support framework for epithelium

- **Adipose**: Beneath skin,stores fat

NEET 2017

Dense connective tissue
Fibres & fibroblasts are compactly

- **Dense regular**: Collagen fibre present in rows b/w parallel bundles of fibres. Eg- tendon(bone to muscle),ligament (bone to bone)

NEET 2022

- **Dense irregular**: Oriented differently, contain fibroblast & mostly collagen. Eg- skin

Specialised connective tissue

NEET 2014

CARTILAGE- Solid,pliable,resists compression. Chondrocyte cells present in self made cavity. Present on nose tip,ear pinna, b/w bones of vertebra,lips & hands of adults.

BONE-hard, non-pliable & rich in Ca salts,collagen fibres. Osteocytes are present in lacunae. Bone marrow—> production of RBC. Long bone have weight gaining function.

BLOOD

Muscular tissue

These fibres are composed of myofibrils they contract(for any stimulus) & relax in coordinated fashion

Skeletal muscle

Synectium

*attached to skeletal bone
*eg- Biceps(they are arranged in parallel fashion held by connective tissue)
*striated/striped,voluntary.

Smooth muscle

*fusiform(taper at both ends)
*do not shows striations → NEET 2021
*cell junction hold them together(involuntary)
*wall of blood vessel,stomach, intestine contain these muscles

Cardiac muscle

*contractile tissue
*cell junction fuse plasma membrane and make them stick together.
*intercalated disc(communication junction) makes all cell to contract at single time.

AIPMT 2011
NEET 2021

Neural tissue

Unit of neural system are nervous which are excitable cells the neuroglial cells make up more than half the volume of neural tissue in our body which protection & support neurons. When it is stimulated,an electrical disturbance travels along its plasma membrane.

AIPMT 2009
NEET 2022

Our heart contain all four type of tissues. The complexity in organ and organ system displays discernable trend which is called as evolutionary trend

COCKROACH

{ Periplaneta americana }

Introduction

* May be bright yellow/red/ green coloured in tropical regions.
* size - 1/4 inch to 3 inch (0.6-7.6cm)
* they have flat extension of upper body wall that concoels head.
* they are serious pests & vectors of several diseases.

Morphology

metamerically Segmented & Schizocoelom present (NEET 2016)

* 34-53 mm long wings(beyond abdomen tip in male)
* body of cockroach = head + thorax(prothorax,mesothorax,metathorax)+ abdomen
* the exoskeleton has hardened plates called sclerites {dorsal —> tergite , ventral—> sternite} that are joined by articular memb. (Arthrodial membrane).
* triangular head lies anteriorly at right angle to body axis(longitudinal). Head- 6 segments, thorax- 3 segments, abdomen-10 segments.
* mobility in all direction due to flexible neck.
* head capsule bear compound eye.
* antennae(help in monitoring env.) arise from membranous sockets lying in front of eye.
* mouth is of biting & chewing type.
* mouth parts = labrum(upper lip) + labium(lower lip) + pair of mandible & maxilla + hypopharynx(tongue) (NEET 2021)
* the head is connected to thorax by short extension of prothorax known as neck/pronotum.
* each thoracic segment bear a pair of walking legs. First pair of wings(tegmina/forewings) -> mesothoracic(opaque & dark coloured to cover hind wings), second pair of wings (hindwings)-> metathoracic(for flight/transparent)

NEET 2022

NEET 2015

Segments in abdomen & respective organs

IN FEMALE- 7th boat shaped sterna, {7th,8th,9th sterna} forms brood/genital pouch which contains gonopore,spermathecal pore & collateral glands. → NEET 2021, 18

IN MALE- {9th,10th terga + 9th sterna} forms genital pouch/ chamber contains dorsal anus,ventral male genital pore,gonapophysis.

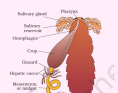
In male anal style are present. → AIPMT 2012, NEET 2013

IN BOTH- 10th segment bears anal cerci(filamentous structure) → NEET 2021

ANATOMY OF COCKROACH

Digestive system

*Alimentary canal (foregut+midgut+hindgut)
* mouth(salivary gland)—>tubular pharynx—>oesophagus—>crop(food storing)—>gizzard/ proventriculus(secrete gastric juice,outer lined by circular muscle & inner 6 high chitinous plate called teeth which grind food). —>6,8 blind tubules (hepatic ceaceae)—>100-150 yellow coloured malphigian tubule(help in removal of excretory waste from haemolymph). —> hindgut(broader than midgut)—>anus

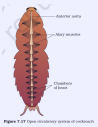


NEET 2021

derived from ectoderm (NEET 2019)

Blood vascular system

Open type,blood vessels (poorly developed) open into haemocoel. Blood is haemolymph(plasma+haemocytes), heart lies at mid dorsal line of thorax & abdomen. It is differentiated into funnel shaped chambers with ostia on either side. Blood is entered through ostia and pumped anteriorly to sinuses again.



Respiratory system

Trachea that open through 10 pairs of small holes called spiracles. Present on lateral side of body.
Tracheoles(subdivisions) carry oxygen from air to all parts. The opening of spiracles is regulated by the sphincters.
Exchange of gases takes place by diffusion.

Excretion

Performed by malphigian tubules,each tubule is lined by glandular and cilliated cells. They convert N2 waste into uric acid. The fat body ,nephrocytes & urecose glands also help in excretion.

Potassium urate

AIPMT 2015

Nervous system

Series of fused segmentally arranged ganglia joined by paired longitudinal connective on the ventral side. 3 ganglia in thorax & 6 ganglia in abdomen. Head holds a bit of nervous system and rest is situated on ventral(belly) side of body. If head is cut off a cockroach it will be alive for 1week. Brain is represented by supra-oesophageal ganglion which supplies nerves to antennae & compound eyes. SENSE ORGANS- antennae,eyes,maxillary palps,labial palps and cerci. Compound eyes are located on dorsal surface. Each eye consist of 2000 omantidia (hexagonal) because o which he can see several images of an object. This vision is MOSAIC vision(more sensitivity,less Resolution) {nocturnal vision}

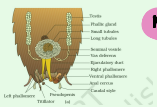
NEET2012

Reproductive system

Male reproductive system

One testis lying on each lateral side in 4th - 6th abdomen. Vas deferens from each testis open into ejaculatory duct thr' seminal vesicle which furthers opens into male gonopore situated ventral to anus. Mushroom gland is present in b/w 6th-7th abdomen which function as an accessory reproductive gland. External genitalia are represented by male gonapophysis or phallomere(chitinous asymmetric struct. surrounding male gonopore). Sperms are glued in seminal vesicle & formed into bundles called spermatophores, which are discharged during copulation.

NEET 2016



Female reproductive system

Ovaries lie laterally in 2th-6th abdomen. 1 ovary = 8 ovarian tubules/ovarioles containing a chain of developing ova. Oviduct from each ovary unite to form median oviduct/vagina which opens into genital chamber. Sperms are transferred thr' spermatophores. Their fertilised eggs are encased in capsules called oothecae(dark reddish to blackish brown capsule -3/8" (8mm) long). They are dropped or glued at a surface near a food source. Female produces 9-10 ootheceae, containing 14-16 eggs each. Development is through nymphal stage which is known as paurametabolus. Nymph grows by moulting 13 times to reach the adult form. Next to last stage have wing pods but only adult cockroach have wings.

There is no economic use of cockroach. They are pests because spoil food & contaminate it with their smelly excreta, by this they can transmit a variety of bacterial diseases.

Earthworm

1. Gizzard is found in the 3rd segment or 3rd & 9th segment. It helps in grinding particles of soil & decaying leaves (AIPMT 2011)
2. Typhlosole ↑ the absorptive surface of the intestine (AIPMT 2011)

Earthworm's food (AIPMT 2012)

Cell: The unit of life

A living being have cell that a non living doesn't have

What is a cell?

Unicellular organisms have independent existence and capable of performing the essential functions of life. Anton Von Lewenhoek described living cell & robert hook described first dead cell. Robert brown discovered nucleus.

Cell theory!

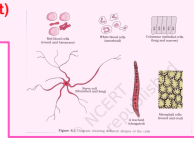
In 1838, Mathias Schleiden, a german botanist concluded that plants are composed of many different cells. In 1839, Theodre Schwann,British zoologist discovered plasma memb. in animals, showed cell wall in plants & told that "animals & plants are composed of cells". In 1855, Rudolf Virchow explained *Ominis cellula e cellula.*

AIPMT 2003

NEET 2019

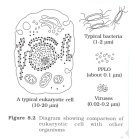
An overview of cell😉

Cell contain dense memb. bound structure,nucleus contains chromosomes,cytoplasm is main arena of cellular activities. Different chemical reactions in cell makes it living. Prokaryotic cell lacks memb. Bound cell organelles. Ribosomes are non memb. bound & found in chloroplast,mitochondria & rough ER. In animal centrosome(non memb. bound) help in cell division. Sizes of different cells:- Mycoplasma-0.3um , RBC- 7um , bacteria- 3-5um , nerve cell- 1m (longest)



Prokaryotic cells

(Bact.,BGA,mycoplasma,PPLO)



(AIPMT 2013)

They are smaller & multiply faster than eukaryotes. Types of bacteria are bacillus,cocci,spiral,vibrio. All have cell wall Except mycoplasma. They have naked genetic material,have genomic DNA (single chromosome/circular DNA),have PLASMID(small circular DNA outside genome) which gives resistance to antibiotics. They have inclusion bodies. And also have MESOSOME (infoldings of plasma membrane)

They have no membrane bound organelles (AIPMT 2015)

Cell envelope & it's modification

NEET 2013

It is present in most of bacterial cells. It includes glycocalyx(outer),cell wall(mid) and cell memb.(inner). Cell envelope acts as protective unit. Glycocalyx could be loose sheath called slime layer or maybe tough as capsule. Cell wall prevent from bursting or collapsing.

BACTERIA CAN BE:- gram positive or gram negative on basis of different composition in cell enveelope.

In some prokaryotes,chromatophores(membranous extensions) are present which store pigments. Bacterial flagellum = filament + hook + basal body.

Pilli—> elongated tubular structure made up of special protein.

Fimbrae—> bristle like fibres help to get attached to substratum.

AIPMT 2015
NEET-II 2016

MESOSOME

* may be in the form of vesicles, tubules,lamellae.
* cell wall formation.
* DNA replication & distribution to daughter cells.
* respiration.
* secretion processes.
* increase surface area of cell membrane.
* enzymatic contect.

AIPMT 2000

Ribosomes & inclusion bodies

In prokaryotes, ribosomes are associated with the plasma membrane(15nm x 20nm). It have 2 subunits 50s & 30s i.e. total 70s ribosomes. Several ribosomes attach to single mRNA to form polyribosome. Or polysome. These ribosomes translate mRNA to protein.

INCLUSION BODIES- Several food material is stored in the form of it in cytoplasm. They are not bound with memb. Eg- phosphate granules,cyanophycean granules & glycogen granules. Gas vacuoles are found in Blue green,purple & green photosynthetic bacteria.

NEET 2020

Eukaryotic cells

Compartmentalisation is present thr' presence of memb. Bound organelles. Have cytoskeleton structures. All eukaryotic cells are not identical.

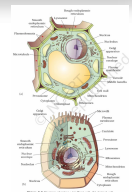
Cell membrane

AIPMT 2010

Electron microscope was discovered in 1950s. Structure of RBC revealed lipids arranged within memb. with polar head outwards & hydrophobic tail inner side.(membrane also contains cholestrol). Lipid content mainly consists of phosphoglycerides. Later it was proved that membrane also contain protein & carbohydrates. RBC memb.= 40% lipid + 52% protein

protein can be PERIPHERAL PROTEIN(lie on surface) or INTEGRAL(partially or totally buried in memb.)

In 1972 Singer & Nicolson gave fluid mosaic model in wwhich lipid have quasi fluid nature and proteins move laterally within bilayer. This ability is measured as fluidity which is important for cell growth, intercellular junction,secretion,endocytosis, cell division,transport(neutral solutes by passive transport).



Centriole is present only in animal cell.

Cell wall

Non living rigid structure. Helps in cell to cell interaction. Algae cell wall contains cellulose, galactons,mannans, CaCO3.

Cell wall of young plant is primary which is capable of growth but secondary wall develops innerly as cell matures. Middle lamellae is formed of Ca2+ pectate which holds cells.

AIPMT 2009

Endomembrane system

Function of ER,golgi apparatus,lysosome & vacuoles are coordinated hence they are included in endomembrane system.

The endoplasmic reticulum

Divides intracellular space in 2 compartments i.e. luminal(inside) & extra luminal(cytoplasm)
ROUGH ER- Protein synthesis & secretion. They are continuous with memb. Of nucleus.
SMOOTH ER-Lipid synth& steroid hormone synthesis.

Golgi apparatus

Discovered by Camillo Golgi in 1898. They consist of many flat,disc like, sacs or cisternae of diameter 0.5um-1um. Which are stalked parallel to each other. The cisternae are concentrically arranged near nucleus with convex cis/forming face & concave trans/maturing face which are interconnected. Performs packaging to deliver outside or inside cell & forms glycoproteins & glycolipids. Materials in form of vesicles are passed to cis from ER —> processing takes place —> packaged material leaves from trans face.

NEET 2018
AIPMT 2011

Lysosomes

They are memb. bound vesicular structure formed by golgi rich in hydrolytic enzymes(lipases, proteases,carbo hydratases) which are activate at acidic pH.

NEET 2019

Vacuoles

Contains water sap,excretory product,materials (not useful). In plants vacuole occupy 90% space. They are layered by tonoplast which allows active transport. In amoeba contractile vacuole performs excretion & in protist food vacuole are formed by engulfing food particles.

Mitochondria

Specifically stained,sausage shaped/ cylindrical (0.2-1um or avg. 0.5um in diameter & 1- 4.1um in length). Its inner memb. divides it into outer & inner compartment. Outer memb. forms continuous limiting boundary for organelle & cristae increases surface area which is site for aerobic respiration. Called power house of cell, inner memb. Have associated enzymes. Matrix = single circular DNA+ RNA Molecules+ 70s ribosomes+ components required for proteins synthesis. Mitochondria divide by fission.

NEET 2019

Plastids

Found in all plants & euglenoids,easily available under microscope,bear pigments.
CHLOROPLAST-contain chlorophyll & carotenoid pigments(for light trapping).
CHROMOPLAST-carotene,xanthophylls(fat soluble carotenoid pigments), give red,yellow,orange colour.
LEUCOPLAST-colourless plastids which store nutrients. For eg- Amyloplast(store carbohydrate in potato),elaioplast(store oil & fat),aleuroplast(store protein).
Majority of chloroplast(width:2-4um, length: 5-10um) are found in mesophyll cells. Chlamydomonas have 1 chloroplast per cell , mesophyll have 20-40 chloroplast per cell.
Grana are also called intergranal thylakoids.
Membrane of thylakoids enclose lumen. Stroma contains small,double stranded circular DNA & 70s ribosomes.

Ribosomes

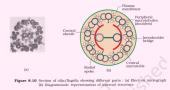
In 1953 discovered by George Palade under electron microscope.
Composed of RNA & proteins.
80s=60s+40s
And 70s=50s+30s where 's' is svedberg's unit stands for sedimentation coefficient i.e. measure of density & size.

Cytoskeleton

Network of filamentous proteinaceous structures present in cytoplasm.
Involved in mech. support, maintenance of shape of cell.

Cilia & flagella

Hair like outgrowths,cilia are like oars & help in cell movement. They both are covered with cell memb. Their core(called axoneme) have many microtubule running parallel to axis. Axoneme arrangement (9+2 array) = 9 pair doublets of radially arranged microtubule + centrally placed 1 pair microtubule. Central tubules are connected by bridge and enclosed in central sheath and sheath is connected to one of the tubules of each doublet by radial spoke. Total radial spokes are 9. Peripheral doublets are interconnected by linkers. Both emerge from centriole like structure called basal body.



Centrosome & centriole

Centrosome is an organelle usually containing 2 cylindrical structures called centrioles surrounded by amorphous pericentriolar materials & lie perpendicular to each other & are arranged like cartwheel. They are made up of 9 triplet of peripheral tubular protein which are linked. It's centre part is hub(proteinaceous) which is connected to triplet by radial spokes(proteinaceous). They form base of cilia,flagella & spindle fibres.

Nucleus

Discovered by Robert Brown in 1831 & material stained by basic dye was named chromatin by Flemming.
Nucleolus may be one or more. Nuclear envelope consist of 2 parallel memb. with a space(10-50nm) called perinuclear space. Pores are formed by fusion of 2 memb. Mature RBC & Sieve tube cell lacks nucleus.
Nucleolus is membrane less & site for RNA Synthesis(from ribosomes). More nucleolus hence more protein synthesis. Chromatin = DNA + histones(basic protein) + non histone protein + RNA. A single human cell have 2m long thread of DNA distributed among his 46 chromosomes. Every chromosome has primary constriction called centromere & disc like structure kinetochores. Sometimes few chromosome have nonstaining secondary constriction at a constant location which gives the appearance of small fragment called satellite.

NEET 2018

Chromosomes

Metameric	Sub-metacentric	Acrocentric	Telocentric
Centromere is middle,2 equal arms.	Centromere slightly away from mid. Short & long arm found.	Centromere present near at end.	Centromere at terminal.

NEET 2018 ,22

Microbodies

They are Memb. Bound vesicles containing enzymes. They are found in both plant & animals.

Biomolecules

They are chemical substance responsible for controlling physiochemical process within a living system or non living components that make living system. Relative abundance of C & H are more in living system is higher than in earth's crust.

Methods for detecting different components in living system

For organic comp. extraction

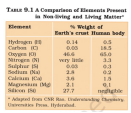
Take any living tissue(a vegetable or a piece of liver) & grind it in trichloroacetate(Cl_3CCOOH) using mortar & pestle. On straining by cheese cloth or cotton & we would obtain two fractions.

- **FILTRATE/** acid soluble — Cytoplasmic composition. Rich in organic compounds (phosphate & sulphate)
- **RETENTATE/** acid insoluble — Macromolecules from organelles

For detecting inorganic compounds

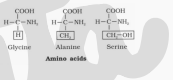
Weigh a small amt. of living tissue (wet weight) & dry it. Remaining material gives dry weight. Burn it all carbon comp. get evaporated & ash contains Ca,Mg.

Basically all carbon compounds in living tissue are biomolecules.



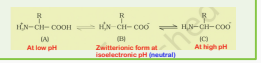
α- Amino acids

Organic comp. containing amino group & acidic grp. as substituents on the same carbon i.e. α-carbon. They are substituted methanes. They contain four groups - amino,hydrogen,carboxyl grp,variable/alkyl grp(R). Amino acids which occur in proteins are of 20 types



PROPERTIES OF AMINO ACIDS:-

1) On the basis of no. Of amino, COOH group a.a are of 3 types:- ACIDIC(glutamic acid),BASIC(Lysine),NEUTRAL(VALINE).
2) Aromatic a.a (amino acids):- tyrosine, phenylalanine, tryptophan
3) ionisable nature of -NH2 & -COOH group {in different pH}



Essential aā → cannot be synthesised by the body eg - lysine, leucine, isoleucine Tryptophan. (AIPMT 2010)

Non-essential aā - eg glycine, alanine etc

Lipids

(Water insoluble)
They could be simple fatty acids or glycerol (simple lipid)

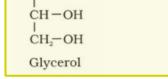
AIPMT 2012

Fatty acid

(Carboxyl group attached to R) where R can be (C1 - C19).
Eg- palmitic acid (16C including -COOH), Arachidonic acid(20C including -COOH).
They can be saturated or unsaturated.

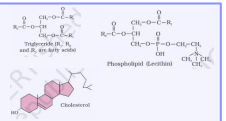
$CH_3-(CH_2)_{14}-COOH$
Fatty acid (Palmitic acid)

Glycerol (Trihydroxy propane)



Neural tissue have lipids with more complex structure.

Many lipids have both fatty acids esterified with glycerol. Then they can be mono,di,tri,poly-glycerides. NEET 2016
They are also called fats & oils based on melting point. Oils have low melting pt. (eg- gingelly oil) hence remain requid in winters. Some lipids have phosphorus & a phosphorylated organic compound in them which are called PHOSPHOLIPIDS.
Eg- LECITHIN (found in cell memb.) AIPMT 2012



NITROGEN BASES + **Sugar** → **NUCLEOSIDE** + **Phosphate** → **NUCLEOTIDE**

NITROGEN BASES: Eg- Adenine,guanine, cytosine,thymine, uracil have heterocyclic ring. NEET 2016

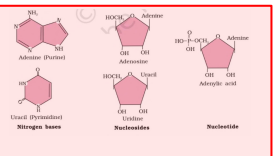
Sugar: Eg-ribose

NUCLEOSIDE: Eg- adenosine, guanosine,cytidine ,thymidine,uridine

Phosphate: Esterified with sugar

NUCLEOTIDE: Eg- adenylic acid, guanylic acid, cytidylic acid, thymidylic acid, uridylic acid.

DNA & RNA contains only nucleotide.



Metabolites

Primary metabolites

Includes amino acid,sugars,basic organic compounds. Found in animal tissues. Their role in metabolism can be easily identified. Compose the basic cell structure.

Table 9.3 Some Secondary Metabolites

Pigments	Carotenoids, Anthocyanins, etc.
Alkaloids	Morphine, Codeine, etc.
Terpenoides	Monoterpenes, Diterpenes etc.
Essential oils	Lemon grass oil, etc.
Toxins	Abrin, Ricin
Lectins	Concanavalin A
Drugs	Vinblastin, curcumin, etc.
Polymeric substances	Rubber, gums, cellulose

Secondary metabolites

Includes alkaloids,flavonoids,rubber,essential oils,antibiotics,coloured pigments, scents, gums, spices. Found in plant,fungal & microbial cell. Their role in metabolisms is not definite. They are useful for human welfare (eg-rubber, drugs,spices, scents, pigments) & also have some ecological importance.

Biomolecules

Biomicromolecules

Molecular weight less than 1000 Da. Found in acid soluble pool & have molecular wt. as 18-800 Da.

Table 9.4 Average Composition of Cells

Component	% of the total cellular mass
Water	70-90
Proteins	10-15
Carbohydrates	3
Lipids	3
Nucleic acids	5-7
Ions	1

Biomacromolecules

Molecular weight in range of 10,000 Da except for lipids. Found in acid insoluble pool & except lipids all are polymeric. Eg-polysaccharides,proteins,nucleic acids, lipids

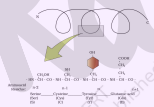
Why lipids are found in acid insoluble pool?

Lipids are arranged in structure like cell memb. On grinding tissue,they get broken & form vesicles which are water insoluble hence found in macromolecular fraction. Lipids are not strictly macromolecules.

Proteins

Introduction

They are polypeptide i.e. linear chain of a.a linked by peptide bonds. They are heteropolymers of a.a(20) eg-alanine,cystine,proline, tryptophan,lysine



Amino acids can be essential(dietary) or non essential(synthesised by body)

Structure of protein

PRIMARY-sequence of a.a i.e. positioned information in a protein which is 1st,2nd a.a. A protein is imagined as a line. Left end has 1st a.a (N-terminal a.a) & right end has last a.a (C-terminal a.a) where N & C stands for amino & carboxyl group.

SECONDARY-originally the structure of protein is not linear,the thread is folded in the form of a helix. In proteins only right handed helices are observed. Those folded portions are called as secondary structure. It can be alpha-helix or beta-pleated.

TERTIARY-The long protein chain is also folded upon itself like a hollow wooden ball,giving rise the tertiary structure. It's 3-D view is important for many biological activities.

QUATERNARY(Architecture of a protein)-proteins made up of more than one polypeptide in which the polypeptide is itself folded & again get folded upon other polypeptide.

Adult human Hb consists of 4 subunits. Two of these are identical to each other. Hence two subunits of α-type & two subunits of β-type together constitute Hb.

α-helix ← Secondary Structure → β-pleated

Functions of protein

Transport nutrients across membrane, fighting with infectious organisms, hormones, enzymes.

Collagen is most abundant protein in animal world & RubisCO is most abundant protein in biosphere. NEET 2020

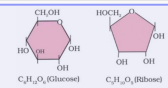
Table 9.5 Some Proteins and their Functions

Protein	Functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Insulin	Hormone
Antibody	Fights infectious agents
Receptor	Sensory reception (smell, taste, hormone, etc.)
GLUT-4	Enables glucose transport into cells

Polysaccharide (Acid insoluble pellet)

Long chain of sugars,made up of monosaccharides (building blocks). Eg-cellulose {made up of only glucose as monomer(HOMOPOLYMER)}, glycogen,starch,inuline

AIPMT 2003 — Variant — Polymer of fructose



Sugars (Carbohydrates)

Right end is reducing & left end is non reducing. Starch forms secondary structure that's why holds Iodine & gives blue colour but cellulose doesn't have that structure.

AIPMT 2002

Paper made from plant pulp and cotton fibre is cellulosic.

Complex polysaccharide

Made up of amino-sugars & glucasamime, N-acetyl galactosamine. Eg-chitin(homopolymer)

Complex again

Seen in fungal cellwalls and arthropods. (NEET 2013)

Branched structure of polysaccharide(glycogen)

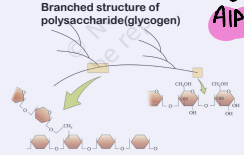


Figure 9.2 Diagrammatic representation of a portion of glycogen

Nucleic acids (Acid insoluble pellet)

They are polynucleotide,possess secondary structure. Their bulding block is a nucleotide.

Components of nucleotide

HETEROCYCLIC COMPOUND
Nitrogenous bases:-
- Adenine, Guanine — Substituted purines
- Uracil, Cytosine, Thymine — Substituted pyrimidines

MONOSACCHARIDE (SUGAR)
Can be either of the two
- RIBOSE (Monosaccharide pentode) [Ribonucleic acid RNA]
- 2'deoxyRIBOSE [Deoxyribonucleic acid DNA]

PHOSPHORIC ACID/ PHOSPHATE

Skeletal heterocyclic ring is called as purine & pyrimidine respectively.

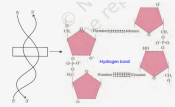
Nature of bond linking monomers in a polymer

In polypeptide a.a are linked by peptide bond [CO-NH]

In polysaccharide monosaccharide are linked by glycosidic bond.

By dehydration

Model of DNA was given by Watson & Crick, which says that DNA exist as double helix, 2 strands of polynucleotideare antiparallel,have sugar-phosphate backbone. Nitrogenous bases are projected more or less perpendicular to this backbone but face inside.



At each step strand turns 36°. One full helical strand would involve 10 steps(basepair). In a line diagram pitch would be 34A°. And rise per basepair is 3.4A°

AIPMT 2003
AIPMT 2007

In nucleic acid phosphate links to 3'C of one sugar of one nucleotide to 5'C of sugar of other nucleotide. Bond b/w phosphate & hydroxyl of sugar is ester bond. & as it is present on either sides hence called phosphodiester bond.

Nucleic acids have secondary structure. Eg- DNA

A & G of one strand compulsorily base pairs with T&C respectively on other strand.

This structure is known as β-DNA.

Dynamic state of body constituents- concept of metabolism

Turn Over → All the biomolecules undergo turnover means constantly being changes into some other biomolecules via reactions. Together all this chemical reactions are called & METABOLISM(transformation of biomolecules). Eg- conversion of amino acid in amine by release of CO_2,removal of amino group in nucleotide base,hydrolysis of glycosidic bond in disaccharide.

Metabolites are converted into each other in a series of linked reactions called metabolic pathways (can be linear or circular). Flow of metabolism thr'pathway has definite rate & direction which is known as dynamic state of body constituents. Every chemical reaction is catalysed. Eg- dissolving CO_2 in H_2O the catalysts are proteins (enzymes).

Metabolic basis for living!

Anabolic pathway
1) Requires energy
2) simpler to complex
3) eg- acetic acid + energy —> cholestrol

Catabolic pathway
1) Releases energy
2) complex to simpler
3) eg- glucose by glycolysis into lactic acid & energy in skeletal muscle.

Living organisms store the released energy in the form of chemical bonds. ATP(Adenosine triphosphate) is energy currency. → AIPMT 2000

BIOENERGETICS- branch of biology which deals with the energy related issues.

Ribozymes are nucleic a that behave as enzymes (NEET 2016)

The living state

Blood concentration of glucose in a normal healthy individual is 4.5-5.0 mM,while hormones are present in nanograms/ml.
All living organisms exist in steady state/non-equilibrium i.e. to be able to perform work.
Living process is a constant effort to prevent falling into equilibrium. This is achieved by energy input.
The living state & metabolism are synonymous. Without metabolism there cannot be living state.
Biomolecules are in a metabolic flux.

ENZYMES

Almost all enzymes are proteins

Ribozymes- nucleic acids that behave like enzymes

The chain of enzymes criss crosses itself & pockets are made which are known as active sites in which substrate fits.

Inorganic catalysts work efficiently at high temp. & pressurewhile enzymes get damaged above 40°C. However enzymes from organisms of hotvents,sulphur springs can retain upto 80-90°C. Thermophilic organisms have thermostable enzyme.

Chemical reactions

When bonds are broken or new bonds are formed. Eg-hydrolysis of starch into glucose.
RATE OF CHEMICAL OR PHYSICAL PROCESS-Amt. of product formed per unit time.

$$\text{Rate} = \frac{\delta P}{\delta t}$$

Rate is influenced by temp. Change

RULE OF THUMB-rate doubles or decreases by half for every 10°C change in either direction

$CO_2 + H_2O \xrightleftharpoons{\text{Carbonic anhydrase}} H_2CO_3$ (Carbonic acid)

In absence of enzyme 200 molecules are formed per hour & when we use enzyme 6,00,000 molecules per second (acceleration by 10 million times).

Metabolic pathway-a multistep chemical reaction when each of the steps is catalysed by the same enzyme complex or different enzymes is called metabolic pathway. Eg-glycolysis. In different condition different products are possible. (Eg-yeast,muscles)

How do enzymes bring about such high rates of chemical conversions!

The chemical which is converted into product(P) is called 'substrate(S)' & this conversion takes place via active site present in 3-d proteins.
The substrate diffuse towards active site & enzyme adjusts its size. After undergoing transient phenomenon Enzyme substrate(ES) complex is formed. Afterwards the required product is released (by breaking & making bonds) from active site. The pathway must go through the transition state structure. In the above pathway some infinite unstable intermediate are also formed. The transition state is also unstable cause of high energy.
ACTIVATION ENERGY-difference in avg. energy content of S from that of transition state.
If energy of P is lower than S then it is exothermic or spontaneous process.

NEET 2016

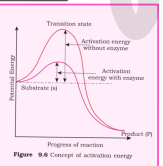


Figure 9.6 Concept of activation energy

NEET 2013

Nature of enzyme action

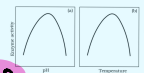
$E + S \rightleftharpoons ES \rightarrow EP \rightarrow E + P$

ES: It's formation is very important & also known as victor henri complex.
EP: Enzyme product complex

Factors affecting enzyme activity

Temperature & pH

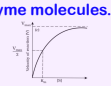
Enzyme show its highest activity at an optimum temp. & pH. Activity declines both below(enzyme get inactive) & above(enzyme get destroyed) the optimum value.



AIPMT 2010, 2011

Concentration of substrate

On increasing conc. First rate increases & then attain a Vmax because enzyme molecule are fewer and there is no other free molecules. There occurs the saturation of enzyme molecules.



Some chemicals resembles with substrate & get attached to enzyme which shut off enzyme activity are called inhibitors & process is called inhibition. More specifically the chemical is called as competitive inhibitor.
Eg-inhibition of succinic acid dehydrogenase by malonate which closely resemble the substrate succinate in structure.

AIPMT 2005, NEET 2020

CLASSIFICATION & NOMENCLATURE of Enzymes

Enzymes are divided into 6 classes each with 4-13 sub-classes & named accordingly by a 4 digit no. Enzymes have suffix of 'ase'

1) OXIDOREDUCTASES/DEHYDROGENASES- catalyse oxidation b/w 2 substrates.
Eg- S reduced + S' oxidised ——> S oxidised + S' reduced
2) TRANSFERASES-catalyse transfer of a group, G(other than H) b/w a pair of substrate.
Eg- S-G + S' ———> S + S'-G
3) HYDROLASED-catalyse hydrolysis of ester,ether,peptide,glycosidic,c-c,c-halide or P-N bonds.
4) LYSASES- catalyse removal of groups from substrate by mechanism other than hydrolysis leaving a bond. 
5) ISOMERASES- catalyse interconversion of optical,geometrical or positional isomers.
6) LIGASES- Catalyse linking together of 2 compounds, eg- joining of C-O,C-S,C-N,P-O bonds.

Co-Factor

There are no. Of cases in which non protein constituents called cofactors are bound to the enzyme to make enzyme catalytically active. The rest protein part of enzyme is called as apoenzyme.

COFACTORS can be of three types

PROSTHETIC GROUP
* organic compounds
* tightly bound to apoenzyme
Eg- in peroxidase catalase haem is prosthetic group which is part of the active site.
It makes water from hydrogen peroxide.

NEET 2019

CO-ENZYMES
* also organic compounds
* essential components - vitamin
* their association with apoenzyme is only transient,usually occuring during the course of catalysis. Eg- coenzyme nicotinamide adenine Dinucleotide (NAD) & NADP contain vitamin niacin.

METAL IONS
Form coordination bonds with side chains at the active site and at the same time one or more coordination bond with the substrate. Eg- zinc is a cofactor for proteolytic enzyme carboxypeptidase.

Catalytic activity is lost when the cofactors is removed from the enzyme which testifies that they play crucial role in the catalytic activity of enzyme.

Rakshita Singh

Cell cycle & Cell division

Growth & reproduction are characteristics of cells indeed of all living organisms.

CELL CYCLE

The sequence of events by which a cell duplicated its genome, synthesise the other constituents & eventually divides is termed as cell cycle. Cell growth(in terms of cytoplasm) is continuous. The events are themselves under genetic control.

CELL DIVISION

Division of parental cell into progeny is termed as cell division.

* Human cell divides in 24 hours {i.e. have interphase of 24 hours}.
* Yeast cell divide in 90 min.
* E. coli divide in 20 min.

Interphase

Phase b/w 2 successive M phases.
Interphase/resting phase (cell is preparing for division,grows & replicates it's DNA) lasts more than 95% of the duration of cell cycle. While only 5% is for M phase (mitosis)

M (mitosis) phase

M phase starts with karyokinesis & ends with cytokinesis.

Some cells which do not divide further or will divide occasionally in case of injury, thus exits G1 phase to enter an inactive stage called guiescent stage (Go). The cell remain metabolically active but doesn't proliferate unless called on to do so.

Gap-1 phase

Cell grows & is metabolically active. It is interval b/w mitosis & initiation of DNA replication.

Synthesis phase

DNA synthesis/ replication begins in nucleus but not the chromosomes , centriole duplicates in cytoplasm.
If cell is diploid before s phase then after s phase it will remain diploid.

It is the longest phase (NEET 2016)

Gap-2 phase

Protein synthesis takes place & cell is ready to divide.

MITOSIS

It is a dramatic phase of cell cycle
Means equational division since no. of chromosomes in parent & progeny is same.
Mainly occurs only in diploid cells of animals but may also take place in some haploid cells of plants.

Significance of mitosis

In some social insects (drone of honeybee),lower plants haploid cell also divide by mitosis.
Growth of multicellular organisms is due to mitosis.
It is essential for cell to divide to restore the nucleo-cytoplasmic ratio.
It contributes to the repair of cells (epidermis,wall of gut,blood cells continuously get replaced.
Mitotic division in meristematic tissue(apical & lateral cambium) is responsible for continuous growth of plants.

KARYOKINESIS
(Four stages)

1) PROPHASE

Chromosomal material condenses to form compact chromosomes attached to centromere.
Centrosome (centriole) starts moving towards the poles & each radiates out asters(microtubule).
Spindle fibre + 2 asters => mitotic apparatus
At the end nuclear envelop and all cell organelles get diminished along with nucleolus.

2) METAPHASE

Nuclear envelope completely disintegrated means start of metaphase.
Morphology of Chromosomes can be most easily studied.
Metaphasic chromosomes is made up of 2 sister chromatids held together at centromere.The paired chromosomes align at the metaphase plate (plane of alignment) or equatorial plate with one chromatid connected by its kinetochore(disc-like) to spindle fibre from one pole & another sister chromatid to another pole.

NEET 2016

3) ANAPHASE

Centromeres split & daughter chromatids separate (daughter chromosomes of future daughter nuclei)
Chromatids move to opposite pole.
Centromere of each chromosome remains directed towards pole & hence at the leading edge, arms trailing behind.

4) TELOPHASE

Chromosomes which reached the poles decondense & loose their own identity (Called as chromosome cluster).
nuclear envelope develops, ER, Golgi apparatus, nucleolus reform.

NEET 2013

CYTOKINESIS

Division of cytoplasm
In animals it takes place by cell furrow (in plasma memb.) method.
In plants it takes place by cell plate method because of presence of cell wall. It starts from the centre of cell. The simple precursor cell plate represents middle lamellae b/w walls of 2 adjacent cells.
At the time of cytokinesis, organelles like mitochondria & plastids get distributed.

In some organisms karyokinesis (division of nucleus) is not followed by cytokinesis as a result of which multinuclear condition arises leading to the formation of synectium (Eg- liq. Endosperm of coconut)

Rakshita Singh

MEIOSIS

Introduction

Reductional division (reduces chromosomes no. To half)
Gametes are formed by it (gametogenesis in plants & animals)
It occurs in 2 plases => Meiosis-I & Meiosis-II but DNA replicate only once.
Meiosis-I is initiated after the parental chromosomes have replicated to produce identical sister chromatids at S-phase.
Involves pairing of homologous chromosomes & recombination b/w non sister chromatids of homologous chromosomes.
4 haploid cells are formed at end of Meiosis-II

MEIOSIS-I

Prophase-I

1) Lyptotene-chromosomes are seen under light microscope.

2) Zygotene-synapsis(pairing of homologous chromosomes) occur. Under electron microscope synaptonemal complex is visible. The complex formed by a pair of synapsed homologous chromosomes is called bivalent or tetrad. — NEET 2013

3) Pachytene-longest stage. Tetrads are clearly visible. Recombination nodules (site of crossing over) is visible. Crossing over requires enzyme recombinase. Chromosomes are left linked at the site of recombination at end of pachytene. — NEET 2019, NEET 2014

4) Diplotene-dissolution of synaptonemal complex occurs. The homologous chromosomes try to separate except at recombination site which results in X-shaped structure (called chiasmata) which in oocytes of some vertebrates lasts for months or years. — NEET 2020, 2021

5) Diakinesis-terminalisation of chiasmata takes place. Represents transition to metaphase-I. Chromosomes get fully condensed & nucleolus and nuclear membrane get diminished.

Metaphase-I

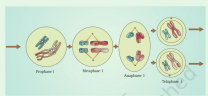
Bivalent chromosomes align at equatorial plate,spindle fibres get attached to kinetochores of homologous chromosomes.

Anaphase-I

Homologous chromosomes separate while sister chromatids remain associated at their centromeres.

Telophase-I

Nuclear envelop & nucleolus reappear & dyad of cells is formed(by cytikinesis). The stage between two meiotic divisions is known as interkinesis which is short lived. No DNA Replication during interkinesis. In many cases chromosomes undergo some dispersion, don't reach extremely extended stage of interphase nucleus.



MEIOSIS-II

Prophase-II

After interkinesis nuclear membrane disappears & chromosomes fully gets condensed.

Metaphase-II

Chromosomes align at equator & the spindle fibres (microtubule from opposite pole of spindle) gets attached to kinetochores of sister chromatids.

Anaphase-II

Simultaneous splitting of the centromere of each chromosome (holding sister chromatids) occurs allowing them to move to opposite poles (shortening of microtubules attached to kinetochores).

Telophase-II

Two groups of chromosomes once again get enclosed in nuclear envelop (cytokinesis results in 4 haploid cells called tetrad of cells).

Significance of Meiosis — AIPMT 2006

Conservation of specific chromosome no. of each species is achieved across generations in sexually reproducing organisms.

Increases genetic variability in population of organisms from one generation to next.

Variations are very important for the process of EVOLUTION.

Transport in plants

For short distance—> by cytoplasmic streaming. & for long distance—> by vascular system(translocation)

(Transport thr' phloem is multidirectional & thr' xylem is unidirectional. Xylem sap-H2O,minerals,org. N2,hormones. Phloem sap- water,sucrose(alkaline) → NEET 2019

Means of transport

Diffusion

Passive,takes place in short dist. Like intercellular space of leaf to outside, random fashion,obvious in gas & liquid,only mean of gaseous transport in plants,slow & does not depend on living system. Rate affected by conc. Gradient, permeability, temp.,pressure.

Table 11.1 Comparison of Different Transport Mechanisms

Property	Simple Diffusion	Facilitated Transport	Active Transport
Requires special membrane protein	No	Yes	Yes
Highly selective	No	Yes	Yes
Transport saturates	No	Yes	Yes
Uphill transport	No	No	Yes
Requires ATP energy	No	No	Yes

Active transport

Special memb. Protein needed, which are called pumps to perform uphill transport. Transport rate reaches max on saturation. These proteins are also specific & sensitive towards inhibitors that react with protein side chains.

AIPMT 2009 NEET 2020

Facilitated diffusion

Passive,more size of obj. means less diffusion rate,more solubility in lipids means higher rate. Protein helps in transport of hydrophilic subst. & they do not set conc. gradient. Transport rate reaches maximum when all proteins are used(saturation). It's specific & sensitive to inhibitors,some channels are always open & others can be controlled. Porins are large proteins,found in plastids,mitochondria,bact. memb. allowing molecules upto size of smaller proteins. Eg- water channels made of 8 aquaporins.

Plant-Water relations

Water is limiting factor(affects growth & productivity). It provides a medium in which subst. dissolve. Watermelon has 92% water,herbaceous plant have 10-15% of their fresh weight as dry weight. Mature corn plant absorbs 3L H2O per day & mustard absorb water equal to mass of plant in 5 hr.

Water potential (Ψs)

Determined by solute potential (Ψs) & pressure potential (Ψp). High conc. Of water means high kinetic energy & thus more water potential. Pure water has highest water potential i.e. zero. Movement of water is from higher to lower water potential. It is measured in Pa & value for pure water without any pressure is zero. If solute is dissolved then it decreases hence all solution have less water potential than pure water. Magnitude of lowering of Ψw is due to solute is called solute potential which is always -ve. For solution at 1 atm pressure Ψs = Ψw & if more pressure is applied to pure water or solution then water potential increase. When cell becomes turgid ,pressure potential which is usually +ve. In plants -ve potential is needed for transpirational pull. { Ψw = Ψs + Ψp }

AIPMT 2007

NEET 2017

Osmosis

In plant cell vacuolar sap contributes to solute potential. In plant cell plasma memb. & tonoplast both are responsible for transport. Osmosis is diffusion of water thr' selectively permeable membrane & occurs on the presence of driving force. Depends upon conc. Gradient,pressure gradient. & movement of water is from high chemical potential to low chemical potential until equilibrium i.e. Ψw1 = Ψw2. Osmotic pressure (extra pressure required to stop the osmosis) is positive & osmotic potential is negative but are same in magnitude. More solute conc. Means more osmotic pressure is required.

Plasmolysis

If external solution balances osmotic pressure of cytoplasm it is said to be isotonic. Further hypotonic(cell swells) & hypertonic(shrinks). In hypertonic first water moves out from cytoplasm & then from vacuole due to which protoplast shrink away from wall(PLASMOLYSIS). Flaccid cell means water flow out & in of cell is in equilibrium. When the plasmolysed cell kept in hypotonic solution the turgor pressure (pressure against wall) increases & cell become deplasmolysed. The pressure exerted by protoplasts due to entry of water against rigid walls is called pressure potential (Ψp)

Imbibition

Special type of diffusion when water is absorbed by solids-colloids causing them to increase in volume. Eg- absorption of H2O by seeds,drywood & pressure developed was used by prehistoric men to split rocks & boulders. The things which are important for imbibition to happen are => affinity b/w absorbent & liquid imbibed and water potential gradient.

Turgor pressure in hypotonic condition is responsible for cell enlargement,cell extension growth.

Long dist. Transport of water!

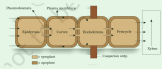
Water & food are transported by mass/bulk flow. Diffusion rate is 2.5 sec per cell if cell is 50um. Mass flow is a result of pressure differences b/w the 2 points which can be achieved either by +ve hydrostatic pressure gradient (eg- garden hose) (root pressure) or -ve hydrostatic pressure (suction thr' straw) (transpiration). It is unlike diffusion that diff. substance move independently on their conc. Gradient. Also xylem transports N2 & hormones while phloem transports inorganic solutes.

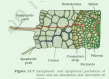
How do plants absorb water?

Root hairs (increase surface area) absorb H2O purely by diffusion & then water come by 2 pathway!

*APOPLAST PATHWAY-mov. of water thr' cell memb. in spaced except casparian strips,does not involve crossing cell memb. , dependent on gradient. Mass flow occur thr' adhesive & cohesive property of water.

*SYMPLAST PATHWAY-system of interconnected protoplast,slower because water needs to enter cell memb.,aided by cytoplasmic streaming. In hydrilla leaf movement of chloroplast is due to cytoplasmic streaming. Most of water move by apoplast because cortical cells are loosely packed but ultimately it is symplastic. In young stem H2O enters directly in xylem vessels/tracheids which are part of apoplast. In mycorrhiza (pinus) hyphae of fungus absorb H2O & min. And demand sugar & N-containing comp. from plant. Pinus cannot germinate without mycorrhiza.





Water movement up a plant!

Root pressure

Water follows its potential gradient & increase pressure in xylem which is +ve & it is called root pressure. Can push water upto small heights. On a moisture day cut a soft stem from base the droplets ooze due to it.

Guttation on early morning or night is result of root pressure. The greatest contribution of root pressure maybe to re-establish the continuous chains of H2O molecule in xylem which often breaks by tension.

AIPMT 2015

AIPMT 2011 NEET 2020

AIPMT 2015

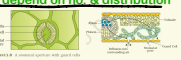
Transpiration pull

It's rate is 15m per hr. Acts in cohesion-tension transpiration pull model. 99% of water absorbed is lost in transpiration. Cobalt chloride turns pink on absorbing water. (Test to recognise transpiration)

Transpiration

In dorsiventral(dicot) leaf there are more stomata on lower side but in monocot there are equal stomata on both sides. The inner wall of guard cell is thick & elastic which becomes crescent shape when turgid. The cellulose microfibrils are arranged radially which helps it to open. Rate of transpiration also depend on no. & distribution of stomata,% of open stomata,water status,canopy structure.

NEET 2018



Ascent of sap depend upon the following physical properties of water:-

1)cohesion- attraction b/w H2O molecules.

2)adhesion- attraction of H2O molecules & polar surfaces(tracheary elements).

3)surface tension-H2O molecules are attracted more in liquid phase than in gaseous phase. These properties give water a high tensile strength i.e. an ability to resist pulling force & high capillarity i.e. ability to rise in thin tubes (tracheary elements).

Force generated can pull xylem sized column of water over 130m high.

NEET 2017

Transpiration & photosynthesis-a compromise

Transpiration performs ascent of sap,supplies H2O for photosynthesis,supply minerals,cool leaf surface by 10-15°C,keeps cells turgid & maintain shape. C4 plants looses 1/2 of the water than that of lost by C3 for same amt. of CO2 fixed.

→ Stomata are open in the day and close during night except CAM (NEET 2016)

Uptake & transport of mineral nutrients

Uptake of mineral ions

Minerals are present as charged particles (cannot pass thr' cell memb.) & their conc. Gradient is opposite. It requires active transport although some travel with H2O passively. Transport proteins of endodermal cell are control points,where a plant adjust the quantity & types of solute that reach xylem. Because of casperian strips endodermis have ability to transport actively ions in one direction only. The process of osmosis keep going due to water potential gradient in roots maintained by active uptake of ions.

Translocation of mineral ions

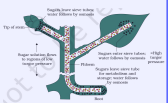
Minerals are unloaded at fine vein endings by diff. Or active uptake by the cells at apical & lateral meristems, young leaves,developing flowers,fruits & seeds, storage organs {chief sinks}. N,P,K,S are remobilised while Ca is immobile mineral. Much amt. of N & small amt. of P & S travel in organic forms such as amino acids. Small exchange of material b/w phloem & xylem also occurs.

Phloem transport:-flow from source to sink

Source & sink are reversed depending on season. Sugar stored in roots act as source in early spring. Phloem sap is mainly water & sucrose but other sugars,hormones,a.a,are transported or translocated thr' phloem. Bulk flow is usually achieved by hydrostatic pressure gradient.

The pressure flow or mass flow hypothesis

Sucrose is transferred into companion cells & then to sieve tube cells (living). It creates hypertonic condition in phloem hence H2O moves into phloem from xylem. The phloem sap moves towards the area of low osmotic potential i.e. sink. Again active transportation is needed to move sugar out which will use sugar converting it into energy,starch,or cellulose. Then water passes out of phloem. Sugars form cytoplasmic strands after passing from sieve plate.



AIPMT 2007

Girdling experiment!

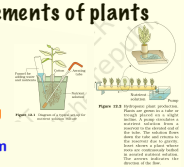
Outer layer of tree is cut to show that food is transported by phloem.

AIPMT 2015

Mineral nutrition

Methods to study mineral requirements of plants

HYDROPONICS-In 1860,Julius Von Sachs, german botanist showed soilless culture which require mineral salts. It is efficient for growing tomato seedless cucumber & lettuce. It helps in identifying essential elements & their deficiency syndrome. Aeration is needed for optimum growth.



Essential mineral nutrients

More than 60 of 105 discovered elements are found in plants like selenium gold & strontium. (Growing near nuclear test sites) some techniques can measure 10^-8 g/ml conc. Of mineral.

Criteria for essentiality

1) element should be supportive in growth or reproduction i.e. without it plant should not complete its life cycle.
2) requirement of any element should be specific & not be replaceable by other.
3) the element must be directly involved in the plant metabolism.

MACRONUTRIENTS-in excess of 10mmol/kg of dry matter. Eg-C,H,N,O,K,S,P,Ca,Mg
MICRONUTRIENTS-less than 10mmol/kg of dry matter. Eg-Fe,Mn,Mo,Cu,Zn,B,Cl,Ni
Benificial elements- Na,Si,Se,Co (needed by higher plants).
Category of essential elements:-
* components of biomolecules-C,H,O,N in carbohydrates,protein,... i.e. as structural elements.
* components of energy related compounds-Mg in chlorophyll & P in ATP.
* activate or inhibit enzymes-Mg2+ activate RubisCO & PEPCO, Zn2+ activate alcohol dehydrogenase, Mo activate nitrigenase.
* changes osmotic potential-K+ in opening & closing stomata.

Role of macro & micro-nutrients

*NITROGEN(NO3-,NOO2-,NH4+)-required in max. Amt., required by meristem & metabolically active cells. Found in protein,nucleic acid,vitamin,hormone.
*PHOSPHORUS(H2PO4-,HPO4-)-required in cell-membrane,found in certain proteins,all nucleic acid,nucleotides & phosphorylation reactions.
*POTASSIUM(K+)-Required by meristem buds,leaves,root tips. Involved in anion cation balance,stomata,activation of enzymes,turgitidy of cells. (NEET 2018)
*CALCIUM(Ca2+)-required by meristem,differentiating tissue,cell wall(Ca2+ pectate),mitotic spindle,enzyme activation,immobile! (NEET 2016)
*MAGNESIUM(Mg2+)-activates enzyme of respiration,photosynthesis,involved in synthesis of DNA & RNA, chlorophyll,helps maintaining ribosome structure.
*SULPHUR(SO42-)-present in cysteine & methionine, component of coenzymes,Vit (thiamine,biotin CoA), and ferredoxin.
*IRON(Fe3+)-constituent of protein involved in ferredoxin & cytochrome. Fe2+ —> Fe3+ (oxidation during electron transfer) activates catalase enzyme & forms chlorophyll.
*MANGANESE(Mn2+)-activates enzymes in photosynthesis, respiration & N2 metabolism. Splits H2O to liberate 02 in photosynthesis. (AIPMT 2012)
*ZINC(Zn2+)-activates carboxylases,needed in synthesis of auxin.
*COPPER(Cu2+)-needed for overall metabolism. Associated with certain enzymes involved in redox reaction & is reversibly oxidise Cu+ —> Cu2+ .
*BORON(BO33-,B4072-)-needed for uptake of Ca2+ ,memb. Functioning,pollen germination, cell elongation,differentiation,carbohydrate translocation. (AIPMT 2003)
*MOLYBDENUM(MoO22-)-component of several enzymes like nitrogenase,nitrate reductase (i.e. N2 metabolism). (AIPMT 2005)
*CHLORINE(Cl-)-help in determining solute conc. & anion-cation balance (along with Na+-K+). Also have use in water splitting.

Deficiency syndromes of essential elements

The conc. Of essential elements below which plant growth is retarded is known as critical conc. (Have importance in agriculture & horticulture).
Deficiency symptom of N,P,Mg are first seen in older leaves because they are mobile. & that of S & Ca are first seen in young leaves.
CHLOROSIS(YELLOWING OF LEAF/LOSS OF CHLOROPHYLL)-Mo,Mn,K,Zn,Mg,Fe,S,N Deficiency
NECROSIS/DEATH OF LEAF TISSUE-Ca,K,Cu,Mg deficiency
CELL DIVISION INHIBITION-Mo,S,N,K deficiency
DELAY IN FLOWERING-M,S,N Deficiency

Toxicity of micronutrients

Any mineral ion conc. In tissues that reduces the dry weight of tissues by about 10% is considered toxic.
MANGANESE TOXICITY-Appearance of brown spots surrounded by chloratic veins.
Manganese competes with iron & Mg for uptake & with Mg for for binding with enzymes, Mn also inhibit Ca translocation in shoot apex. Excess Mn can cause deficiency of Mg,Fe,Ca

MECHANISM OF ABSORPTION OF ELEMENTS

It can be passive or active but usually take place by both.
Movement of ion -> flux (inside is influx, outside is efflux)

First phase

> initial rapid uptake
> into free space or outer space.
> apoplast
> passive movement
> through ion channels (trans membrane proteins) => function as selective pores.

Second phase

> slower
> into inner space
> symplast
> active transport
> ions move by flux.

Soil as reservoir of essential elements

Minerals are available in soil due to weathering of rocks (inorganic salts). Soil also harbours N2-fixig bact.,other microbes,holds water,aeration,acts as matrix that stabilises plant. If mineral need is no is not fulfilled naturally then fertilisers need to used to fulfil the needs. NEED FOR SUPPLY OF FERTILISERS:- N,P,K,S (Macronutrients) & Cu,Zn,Fe,Mn (micronutrients)

METABOLISM OF NITROGEN

Nitrogen cycle

Plants compete with microbes for limited N2 that is available in soil thus N2 is limiting nutrient for natural & agro-ecosystems.

$N_2 \xrightarrow{N_2\text{-fixation}} NH_3 / N_2 \xrightarrow{\text{lightning, UV}} NO, NO_2, N_2O$

Organic N2 of dead matter $\xrightarrow{\text{ammonification}} NH_3$

$2NH_3 + O_2 \xrightarrow{\text{Nitrosomonas/Nitrococcus}} 2NO_2^- + O_2 \xrightarrow{\text{Nitrobacter}} 2NO_3$

$NO_3^- \xrightarrow{\text{Pseudomonas/thiobacillus}} N_2$

NEET 2013

Industry are also source for nitrogen oxides

- This nitrate is used by plant for making a.a & left over nitrate is reduced to nitrogen by denitrification.

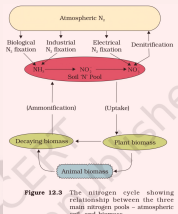


Figure 12.3 The nitrogen cycle showing relationship between the three main nitrogen pools – atmospheric soil, and biomass

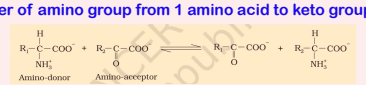
Fate of ammonia

1) REDUCTIVE AMINATION

$$\alpha\text{-ketoglutaric acid} + NH_4^+ + NADPH \xrightarrow[\text{Dehydrogenase}]{\text{Glutamate}} \text{glutamate} + H_2O + NADP$$

2) TRANSAMINATION

Transfer of amino group from 1 amino acid to keto group of a keto acid.



Glutamine & aspargine are important amides found in plants as structural parts of protein which are formed by aspartic acid,glutamic acid by replacing OH by NH2 {i.e. amide have more N tan amino acids.} hence they are sent to xylem vessels. Along with the transpiration stream the nodules of some plants (eg-soyabean) export fixed N2 as ureids (ureids have high N/C (NITROGEN/CARBON) ratio.

Biological N2 Fixation

N2 fixation by living organisms (prokaryotes) by enzyme nitrogenase.
FREE LIVING N2 FIXERS AEROBIC- azotobacter,beijernickia,bacillus, nostoc, anabena(cyanobact.) (AIPMT 2011)

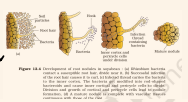
Symbiotic biological N2 Fixation

Rod shaped rhizobium and roots of legumes as alfalfa,sweet clove, sweet pea,lentils, garden pea,broad ban,clover beans.
Most common association on roots is as nodules.
Frankia makes nodules with non leguminous plant(alnus).
Rhizobium and frankia are freeliving in soil but symbiotically fix N2.
CENTRE PORTION of nodule is red/pink due to leguminous haemoglobin (Leg Hb). AIPMT 2015

Nodule formation

Rhizobium multiplies & get attached to epidermal &root hair cell. Root hairs curl & bact. invade in it. Infection thread is prepared leading to cortex of root. Initiate nodule formation in cortex. Special N2 fixing cell are formed. Nodule contain nitrogenase & leg Hb. Nitrogenase is Mo-Fe protein.
Usually rhizobium is aerobic but under N2 Fixing conditions it becomes anaerobic hence a factor called leg Hb is present in nodule because nitrogenase is sensitive towards O2.

↓
acts as O Scavenger
AIPMT 2011



$$N_2 + 8e^- + 8H^+ + 16ATP \longrightarrow 2NH_3 + H_2 + 16ADP + 16P_i$$

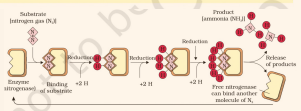


Figure 12.5 Steps of conversion of atmospheric nitrogen to ammonia by nitrogenase enzyme complex found in nitrogen-fixing bacteria

Photosynthesis in higher plants

It is physiochemical process. Living forms on earth depends upon sunlight for energy. In these mindmap photosynthesis is denoted by " Ptsn."

Importance of photosynthesis

1) Primary source of food
2) O2 Liberates

Early experiments ⏳

1) JOSEPH PRIESTLY BELL JAR MINT PLANT EXPERIMENT:- in 1770. He discovered O2 in 1774 & told the role of air in Ptsn. (Foul air concept).
2) JAN INGENHOUSZ:- showed that sunlight is an important factor for removing foul air in his aquatic plant experiment.
3) JULIUS VON SACHS:- in 1854 told that green part of contain green pigment stored in special bodies where glucose is prepared and stored as starch.
4) TW ENGELMAN:- he spread the spectrum and illuminated. Eg- cladophora (green alga) placed in suspension of aerobic bact. Bact. Were found mainly in red and blue light which resembles to absorption spectrum of chl a & b. (NEET2019)
5) CORNELIUS VAN NIEL:- (MICROBIOLOGIST) in place of H2O any H2 donor can also work like H2S in purple and green sulphur bacteria. But here O2 will not be released (proved by radioisotopic techniques).

$2H_2A + CO_2 \longrightarrow 2A + CH_2O + H_2O$ (In presence of light)

$6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$

What do we know?

1) VARIEGATED LEAF EXPERIMENT-presence of sunlight.
2) HALF LEAF EXPERIMENT-CO2 is essential for photosynthesis.(part of leaf enclosed in test tube with KOH soaked cotton).

Where does ptsn takes place?

Mesophyll have large amount of chloroplast arranged along wall to get proper light. The membranous system (grana and other structures) are useful in trapping light & synthesise ATP & NADPH which comes under light reaction.
In stroma synthesis of sugar takes place which comes under dark reaction which depends upon the products of light reaction but it doesn't occurs in dark only. (Not directly light driven)

NEET2018

AIPMT 2019

What is light reaction?

Light reaction or photochemical phase include light absorption, water splitting, oxygen release, formation of ATP & NADPH. The pigments are arranged into 2 discrete photo chemical light harvesting complexes (LHC) within PSI & PS II. LHC Are made up of 100s of protein. All pigments except Chl A form LHS also called antennae. Chl a forms reaction centre (in PSI -> chl a (p700 nm), in PSII -> 680nm

The electron transport

Electrons are excited from PSII & transported to electron acceptor. It transfers electron to an electron transport system consisting of cytochromes which is downhill movement.
Electron are transferred to PSI where they are excited & sent to other electron acceptor with high redox potential & again a downhill transfer takes place which generates NADPH.

HOW MANY PIGMENTS ARE INVOLVED IN PTSN?

By paper chromatography, colour in leaf is due to chl a (bright or blue green), chl b (yellow green), xanthophylls (yellow), carotenoids (yellow to yellow orange) which absorbs different wavelengths of various lights.
Maximum absorption occurs of chl a occurs in blue and red region and max rate of ptsn is also in same range so chl a is chief pigment.
Other pigments absorbs light of different wavelen

The electron transport

Done at inner side of membrane of thylakoid to supply the electron to PSII & release O2.

$2H_2O \longrightarrow 4H^+ + O_2 + 4e^-$

Cyclic & non cyclic photo phosphorylation

Non cyclic is discussed in electron transport. When only PSI is functional & phosphorylation occurs due to cyclic flow of electron then it is known the former.
It can take place in stromal lamellae because it lacks PSII & NADP reductase.
It results in formation of ATP only.
It occurs when only light wavelength beyond 680nm are available.

Chemiosmotic hypothesis

After splitting of water H+ get accumulated in lumen of thylakoids.
When electron move through photosystem the H+ travels from stroma to lumen.
NADP reductase enzyme is present on outer membrane of thylakoid hence it also remove H+ from stroma.
These three events create a proton gradient b/w stroma & lumen. (NEET2016)
This gradient is broken by passing H+ via ATP Synthase i.e. CFo (embedded) & CF1 (outwards) phases to release ATP.
Chemiosmosis requires a membrane, a proton pump, a proton gradient & ATP synthase.
Energy is used to create proton gradient.

Akshita Singh

Where are the ATP & NADPH used?

They are used in the biosynthetic phase/ dark reaction to synthesise sugars.

After world war II Melvin calvin concluded that first product of fixed CO_2 is 3- phosphoglyceric acid or PGA by radioisotopy & using radioactive 14C. PGA is a 3C compound.

After some time it was concluded that in some plants 1st product was again an organic acid with 4C atom i.e. OAA.

Hence based on 2 different 1st product 2 pathways were introduced called C3 & C4 pathway.

The Calvin cycle

important.ieptor of CO_2 is 5C RuBP. RuBP was regenerated. Found in all photosynthetic plants whether C3 or C4. Let us study it in 3 stages.

CARBOXYLATION- CO_2 is fixed or used in carboxylation of RuBP via RubisCO to form 2 molecules of 3PGA.

REDUCTION- lead to formation of glucose which requires 2 ATP & 2 NADPH. (AIPMT 2005)

REGENERATION- it requires 1 ATP & is very much important.

Total in - $6CO_2$, 18 ATP, 12 NADPH

Total out - 1 $C_6H_{12}O_6$, 18 ADP, 12 NADP.

The C4 pathway!

Present in plants which are adopted to dry tropical region. But they also use calvin cycle as main biosynthetic pathway.

C4 plants tolerate high temp., response to more light intensity, lack photorespiration, have greater productivity. Leaves of C4 plant have kranz anatomy i.e. bundle sheath surrounds vascular bundles. Kranz means wreath & is reflection of arrangement of cells.

They have many chloroplast with tough walls impervious for gaseous exchange. Eg- maize & sorghum

Primary CO_2 acceptor is 3C phosphenol pyruvate (PEP) & Enzyme PEPcase. Mesophyll lack RubisCO & OAA is formed in mesophyll.

NEET 2017

OAA forms 3C Malic acid or aspartic acid which goes into bundle sheath & release CO_2 to form C3 compound & that compound further sent to mesophyll.

AIPMT 2008

Photorespiration

Rubisco is most abundant enzyme in world which can bind to O_2 & CO_2 both. It have more affinity for CO_2 but if O_2:CO_2 ~ 1 then for O_2 hence the binding becomes competitive.

If RuBP binds with O_2 then fixation of CO_2 is decreased.

NEET 2020, 2021

NEET 2016

ATP + RUBP + O_2 —> 1PGA + 2C Phosphoglycolate + CO_2

It does not occur in C4 plants because in bundle sheath, as C4 acid breaks CO_2 release i.e. intracellular CO_2 conc. Increase hence RubisCO works as carboxylass more and not oxygenase.

Factors affecting photosynthesis

The plants factors include the no., size, age & orientation of leaves, mesophyll cells & chloroplasts, internal CO_2 conc. & amount of chlorophyll.

blackman's law of limiting factors- if a chemical process is affected by more than 1 factor then which is nearest to its minimal value it is the factor which directly affects the process if its quantity is changed.

Eg- despite of a green leaf, optimal light & CO_2 conditions, the plant may not photosynthesise if temp. Is very low this leaf if given optimal temp. Will start photosynthesising.

Light

At higher light intensity other factors become limiting and chlorophyll may also get breakdown. Light saturation occurs at 10% of full sunlight. For plants in shade or in dense forests, light is rarely a limiting factor in nature.

CO_2 concentration

Major limiting factor. If in atmosphere becomes 0.05% then it will be helpful but if further increased then cause damage. At low light conditions neither group respond to high CO_2 conditions. C4 plants saturate at 360u1l-1 & C3 plants saturate beyond 450 u1l-1. Its conc. Can be increased by using green house crops such as tomato & bell pepper. They are grown in CO_2 rich atmosphere which leads to higher yields.

Temperature

Dark reaction being enzymatic are temp. Controlled. C4 —> high temp. Optimum, C3 —> less temp. Optimum.

Tropical plants have high temp. Optimum & temperate plants have less temp. Optimum.

Water

Water stress also disable availability of CO_2 by closing stomata & also the leaves wilting causes decreasing surface area of leaves & their metabolic activity as well.

Rakshita Singh

NCERT Diagrams for reference

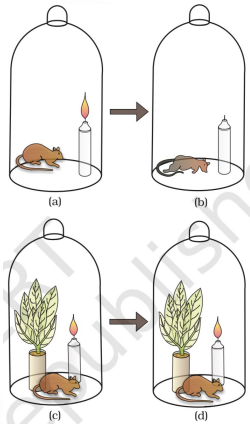


Figure 13.1 Priestley's experiment

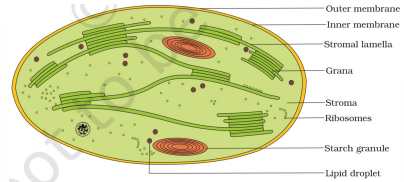


Figure 13.2 Diagrammatic representation of an electron micrograph of a section of chloroplast

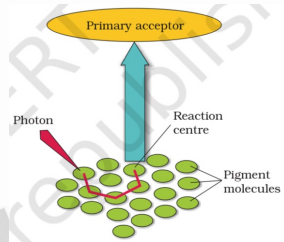


Figure 13.4 The light harvesting complex

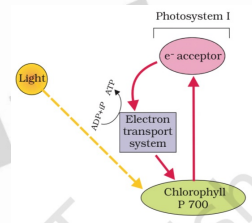


Figure 13.6 Cyclic photophosphorylation

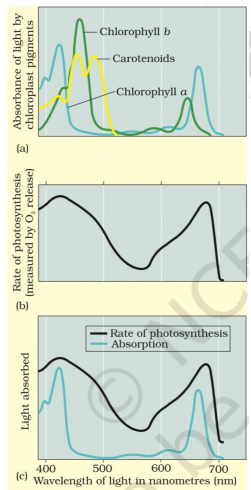


Figure 13.3a Graph showing the absorption spectrum of chlorophyll *a*, *b* and the carotenoids

Figure 13.3b Graph showing action spectrum of photosynthesis

Figure 13.3c Graph showing action spectrum of photosynthesis superimposed on absorption spectrum of chlorophyll *a*

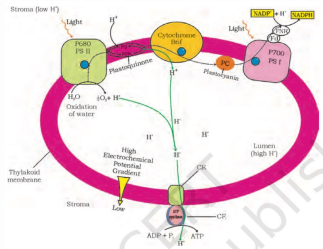


Figure 13.7 ATP synthesis through chemiosmosis

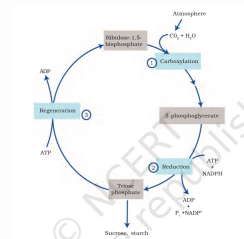


Figure 13.8 The Calvin cycle proceeds in three stages : (1) carboxylation, during which CO_2 combines with Ribulose-1,5-biophosphate; (2) reduction, during which carbohydrate is formed at the expense of the photochemically made ATP and NADPH; and (3) regeneration during which the CO_2 acceptor ribulose-1,5-biophosphate is formed again so that the cycle continues

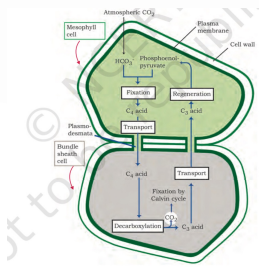


Figure 13.9 Diagrammatic representation of the Hatch and Slack Pathway

Table 13.1 Fill in the Columns 2 and 3 in this table to highlight the differences between C_3 and C_4 Plants

Characteristics	C_3 Plants	C_4 Plants	Choose from
Cell type in which the Calvin cycle takes place			Mesophyll/Bundle sheath/both
Cell type in which the initial carboxylation reaction occurs			Mesophyll/Bundle sheath /both
How many cell types does the leaf have that fix CO_2			Two: Bundle sheath and Mesophyll One: Mesophyll Three: Bundle sheath, palisade, spongy mesophyll
Which is the primary CO_2 acceptor			RuBP/PEP/PGA
Number of carbons in the primary CO_2 acceptor			4 / 4 / 3
Which is the primary CO_2 fixation product			PGA/OAA/Malate/PEP
No. of carbons in the primary CO_2 fixation product			3 / 4 / 5
Does the plant have RuBisCO?			Yes/No/Not always
Does the plant have PEP Case?			Yes/No/Not always
Which cells in the plant have Rubisco?			Mesophyll/Bundle sheath/none
CO_2 fixation rate under high light conditions			Low/ high/ medium
Whether photorespiration is present at low light intensities			High/negligible/sometimes
Whether photosynthesis saturates at high light intensities			High/negligible/sometimes
Whether photorespiration would be present at low CO_2 concentrations			High/negligible/sometimes
Whether photorespiration would be present at high CO_2 concentrations			High/negligible/sometimes
Temperature optimum:			30-40 C/20-30C/above 40 C
Examples			Cut vertical sections of leaves of different plants and observe under the microscope for Kranz anatomy and list them in the appropriate columns.

Respiration in plants

Cells (containing chloroplast) that are most often located in superficial layers carry out photosynthesis.
The compounds that are oxidised during process are known as respiratory substrates.
Green plants & cyanobacterium perform photosynthesis.
Carbon skeleton produced during respiration is used as precursors for biosynthesis of other molecules in cell.

Do plants breathe?

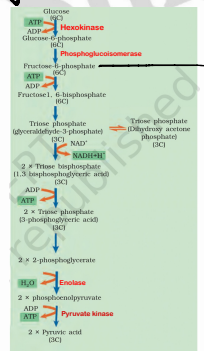
No direst answer for it! But have stomata & lentil for it.
Plants do not need well developed respiratory system because-
1) each plant part is aware of its own gaseous need.
2) they do not have great demands for gaseous exchange.
3) distance for diffusion of gases is not that much large.

Root, stem, leaf respire at lower rates than animal do.
Because of photosynthesis O2 is already available in cell.
Most of cells are in contact with air which is facilitated by loose packing.
Glucose is not oxidised in a single step but in several steps because then most of the energy is lost as heat.
All the living organisms partially oxidise glucose to pyruvic acid and is called glycolysis which takes place anaerobically.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

GLYCOLYSIS

Given by embden, meyerhof, parnas hence also called EMP pathway.
Takes place in the cytoplasm. Pyruvic Acid is the key product of glycolysis.
It includes 10 steps from glucose.
In 1st & 3rd step ATP is used & in 5,6,9 NADH, ATP,ATP are released & in 8 H2O is released.
3 fates of pyruvic acid formed are:
1) lactic acid
2) alcohol fermentation
3) aerobic respiration
For complete oxidation kreb cycle is needed. Fermentation takes place in many prokaryotes & unicellular eukaryotes.
The step where sucrose is converted to glucose in presence of invertase only takes place in plants.

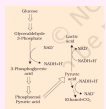


NEET 2019

Figure 14.1 Steps of glycolysis

Fermentation

Pyruvic acid is converted to CO2 & ethanol in presence of alcohol dehydrogenase and pyruvic acid decarboxylase to catalyse the reaction.
(In muscle cell lactic acid is formed in presence of lactate dehydrogenase.) → NEET 2014
In both reaction reducing agent is NADH + H+
In both type of fermentation less than 7 % of energy in glucose is released and not all of it is trapped as high energy bonds of ATP.
Yeast poison themselves to death when con. Of alcohol reaches 13%
Aerobic respiration takes place in mitochondria.



Aerobic respiration

Pyruvic acid is transported to mitochondria and its crucial events are:
1) complete oxidation of pyruvate by stepwise removal of H atoms leaving 3 CO2.
2) Passing of e- To O2 with simultaneous synthesis of ATP.
The first step is done in chondrial matrix & another is on inner membrane.
Pyruvate first undergo oxidative decarboxylation in presence of pyruvate dehydrogenase. (Link reaction) (NEET 2018)

$$\text{Pyruvic acid} + \text{CoA} + \text{NAD}^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{Mg^{2+}} \text{Acetyl CoA} + CO_2 + \text{NADH} + H^+$$

Rakshita Singh

TRICARBOXYLIC ACID CYCLE

$$\text{Pyruvic acid} + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pi \xrightarrow{\text{Mitochondrial Matrix}} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

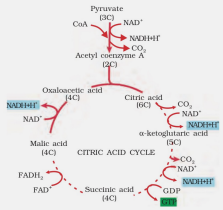
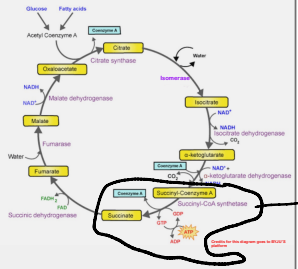


Figure 14.3 The Citric acid cycle

In step of conversion of OAA to citrate citrate synthase enzyme catalyse the process. & the next step is catalysed by isomerase.
Uptil now 2 ATP, NADH & 2 FADH are synthesised.

NEET 2017



NEET2020

ELECTRON TRANSPORT SYSTEM & OXIDATIVE PHOSPHORYLATION (NEET2019)

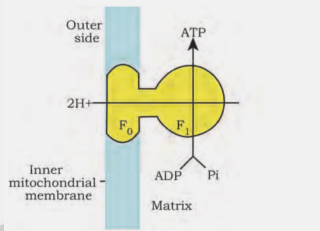


Figure 14.5 Diagramatic presentation of ATP synthesis in mitochondria

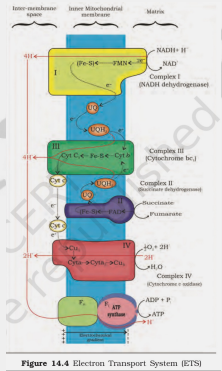


Figure 14.4 Electron Transport System (ETS)

Respiratory balance sheet

Assumption made for calculating net gain are:
1) sequential, orderly pathway functioning.
2) NADH synthesised in glycolysis undergoes oxidative phosphorylation.
3) none of intermediate in the pathway are utilised to synthesise other compounds.
4) only glucose is being respired, no other alternative enters pathway.

But these are not valid in living system. But then also there is net gain of 38 ATP molecules. During aerobic respiration while in anaerobic respiration net gain is of 2 ATP.
NADH is oxidised to NAD+ rather slowly in fermentation but reaction is vigorous in aerobic respiration. (In fermentation only partial breakdown occurs)

Amphibolic pathway

AIPMT 2009

But was traditionally called catabolic.
Glucose is favoured substrate for respiration.
When organism need fatty acid then acetyl CoA must be withdrawn from pathway.
Similarly breakdown & synthesis of protein too respiratory intermediates from the link.

NEET 2016, 21

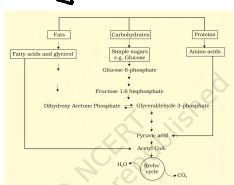


Figure 14.6 Interrelationship among metabolic pathways showing respiration and lipid breakdown (4 different organic molecules to CO_2 and H_2O

Respiratory quotient

$$RQ = \frac{\text{volume of } CO_2 \text{ evolved}}{\text{volume of } O_2 \text{ consumed}}$$

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

$$RQ = \frac{6CO_2}{6O_2} = 1.0$$ (For carbohydrate)

For proteins RQ = 0.9

NEET 2019

$$2(C_{51}H_{98}O_6) + 145O_2 \longrightarrow 102CO_2 + 98H_2O + \text{energy}$$

Tripalmitin

$$RQ = \frac{102CO_2}{145O_2} = 0.7$$ (For fat (tripalmitin))

Rakshita Singh

Plant growth & development

Development = growth + differentiation

Growth

Irreversible permanent increase in size of an organ, or its parts or even of an individual cell. (Occur at expense of energy) Accompanied by metabolic process. Eg- expansion of leaf growth.

Plant growth generally is indeterminate

Unlimited growth in plants due to presence of meristems.
New cells are added always hence it is termed as open form of growth.

Growth is measurable

Growth may be considered as increase in amount of protoplasm.
It can be measured in terms of increase in fresh weight, dry weight, length, area, volume, cell no.
Single maize root apical give rise to more than 17,500 cells per hour.
Watermelon cells may increase in size by upto 3,50,000 times.
Growth in pollen tube is measured by length. In dicot leaf it is measured by surface area.

Shoot apical meristem —> primary growth (elongation of axis)
Dicots & gymnosperms —> lateral meristem
—> vascular cambium (appear later in life)
—> cork cambium

Phases of growth

Meristematic phase (have abundant plasmodesmata), elongation (vacuolation & formation of new cell wall takes place), and maturation phase (proximal to elongation, attains maximum size, wall thickening, protoplasmic modification, most of tissue & cell type.

Growth rates

Increased growth per unit time is termed as growth rate.

Arithmetic growth

Follows mitotic cell division & only 1 cell continue to divide while other differentiates and matures. Linear curve is obtained on l-t graph.

$L_t = L_0 + rt$

L_t = length at time 't'
L_0 = length at time 'zero'
r = growth rate / elongation per unit time.

Here r is relative growth rate i.e. referred as efficiency index which is also a measure of the ability of the plant to produce new plant material. Hence final size depends on initial size.

Geometric growth

Initial growth is slow (lag), & it increases rapidly thereafter at an exponential rate (log or exponential phase).
Here both progeny cells following mitotic cell division retain the ability to divide and continue to do so.
With limited nutrient supply the growth slows down leading to stationary phase.
Sigmoid curve is obtained.

NEET 2015

$W_t = W_0 e^{rt}$

W_t = final size (weight, height, number etc.)
W_0 = initial size at the beginning of the period
r = growth rate
t = time of growth
e = base of natural logarithms

Quantitive comparison b/w 2 living system:-
1) Absolute growth rate- total growth per unit time comparison.
2) Relative growth rate- growth per unit time expressed on common basis.

Conditions for growth

Water(cell enlargement, turgidity) , O2, nutrients and optimum temp. Are important and any deviation from optimum temperature is detrimental to its survival.
growth & further developments linked to water status.
Nutrients help in synthesis of protoplasm.
Environmental signals like light, gravity also affect phases/stages of life.

Differentiation, Dedifferentiation & redifferentiation

Cells of meristem differentiate to form mature cells called differentiation. Eg- to form tracheary element, protoplasm is lost, strong, elastic, lignocellulosic secondary walls develop to handle extreme tension.

Differentiated cells regain capacity to divide is called dedifferentiation. Eg- formation of meristems - interfascicular (from differentiated plant parenchyma) cambium & cork cambium from parenchyma cells.

Dedifferentiated cells again loose capacity to divide is called redifferentiation. Eg- woody dicot tissues.

Growth in plantscan be indeterminate or determinate & differentiation is also open. Differentiation also depends upon locations. Cells away from apex formed root cap & cell towards periphery formed epidermis.

Rakshita Singh

Development

It includes all the changes that an organism goes through during life cycle.
PLASTICITY- plants follow different pathways in response to environment or phases of life to form different kind of structures.
Eg- heterophylly in cotton, coriander & larkspur.
Heterophylly due to environment in buttercup.

Plant growth regulators / phytohormones

[1] characteristics

They could be indole compounds (indole-3-acetic acid, IAA); Adenine derivative (N6-furfurylamino purine, kinetin); caroteinoid derivatives (ABA), Terpene (giberrelic acid, GA3) or gases (ethylene, C2H4)
PGR may be growth promoter. Eg- auxin, gibberellin, cytokinin
Or may be growth inhibitor. Eg- absiccic acid, ethylene (90%)

[2] the discovery of plant growth regulators-

AUXIN- charles darwin& francis darwin saw phototropism in coleoptile od canary grass. FW Went isolated auxin from coleoptile of oat seedlings. (site of transmittable influence) NEET 2015 AIPMT 2009
GIBBERELIN- bakane (foolish seedling) disease of rice seedling was cause by fungal pathogen giberella fujikuroi. E Karosawa in 1926 detected that it was giberrelic acid substance. (Symptoms appear when treated with sterile filtrate of fungi).
KINETIN (cytokinin)- F skoog found that cell division (proliferation of callus) in tobacco internode take place only if with auxin, extraction of vascular tissue, yeast, coconut milk or DNA is added. Skoog & miller named it as kinetin after crystallising it.
Callus is mass of undifferentiated cells.
ABCISSIC ACID (ABA)- during mid 1960's 3 researcher discovered inhibitor B, abscission II & Dormin which were collectively named as abscissic acid (ABA).
ETHYLENE- cousins confirmed release of volatile substance in ripened orange that ripens the banana which was later known as ethylene.

[3] physiological effects of plant growth regulators-

Auxins

> First isolated from human urine.
> IAA & Indole butyric acid (IBA) have been isolated from plant.
> NAA (Napthalene acetic acid) & 2,4-D (dichlorophenoxy acetic acid) are synthetic auxins.
These are used in agriculture & horticulture practices.
> used for plant propagation AIPMT 2010, 2016
> promote flowering in pineapple NEET 2019
> used in tea plantation & hedge making
> causes apical dominance & to overcome it decapitation is done. AIPMT 2006, 2010
> induce parthenocarpy in tomatoes. AIPMT 2006
> used as herbicides
> 2,4 D used to kill dicot weeds but not affect monocot plant.
> control xylem differentiation
> cell division.

Giberellins

> there are 100s of giberrelin (GA1, GA2, GA3...) out of which GA3 is most studied.
All are acidic.
> increase in length of grape stalk
> improve shape of apple
> delay senescence
> speed up malting & brewing
> increase production in sugarcane as 20 tone/acre
> hastens maturity period in juvenile conifers (early seed production)
> promote bolting in beet, cabbage & many plants with rosette AIPMT 2008
> increases length along axis.

Cytokinins

> discovered as purine i.e. kinetin from autoclaved herring sperm DNA which does not occur naturally in plants.
> naturally it is found as zeatin in corn- kernels & coconut milk
> found in rapidly dividing cell zone (root, shoot apice, young fruit)
> helps to produce new leaves, chloroplast, lateral shoot growth.
> adventitious root formation
> overcome apical dominance
> promote nutrient mobilisation
> delay of leaf senescence.

Ethylene

> synthesised by tissue undergoing senescence & ripening fruits
> horizontal growth of seedlings, swelling of the axis.
> apical hook formation in dicot seedlings
> promotes abscission of leaves, flowers.
> increase respiratory rate i.e. respiratory climatic
> breaks seed/bud dormancy
> initiate germination in peanut seeds.
> sprouting of potato tubers
> promote elongation of internode & in petiole also in deep water rice plants which helps leaves & stem to remain above water.
> promote root hair formation.
> initiate flowering & for synchronising fruit set in pineapple. mango- NEET 2019
> induce flowering in mango.
> most used ethylene is ethephon which is aquous solution readily absorbed by plant & releases ethylene slowly.
> ethephon induce fruit ripening in tomato & apple & accelerates abscission in flower & fruits (thinning of cotton, cherry, walnut)
>promotes female flowers in cucumber thereby increases yield.
> most used PGR in agriculture.

Abscissic acid

> regulate abscission & dormancy
> inhibits seed germination
> stimulates closure of stomata & is a stress hormone AIPMT 2014
> by inducing dormancy it helps seed to withstand dessication
> ABA acts as antagonist to GA's AIPMT 2009 NEET 2012

Ankshita Singh

Photoperiodism

Response of plants to period of day/night is termed as photoperiodism.
Duration of dark holds same importance as night. To detect the light leaves are used on a hormone is sent to site of flowering. NEET 2019, 2016

Vernalisation

Prevents precocious reproductive development.
Flowering either quantitatively / qualitatively depend on low temperature. AIPMT 2006, 2012
Enables plant to have sufficient time to reach maturity.
Wheat, barley have 2 varieties (winter & spring)
If winter variety is grown in spring then it may fail to flower hence they are planted in autumn. But spring variety is better. Winter variety is harvested in mid summer.
Another example-> biennials (monocarpic plants) that normally flower & die in the sec. season. Eg- sugarbeet, cabbage, carrot. AIPMT 2012

Seed dormancy

It is under control of endogenous conditions.

REASONS-
> Impermeable hard seed coat.
> presence of chemical inhibitor such as ABA, phenolic acid, para-ascorbic acid.
> immature embryo.

HOW TO OVERCOME SEED DORMANCY?
> by mechanical abrasions using knife, sand paper, etc or vigorous shaking. Naturally these abrasions are provided by microbial action, passage through digestive tract of animal.
> by chilling or treating with GA or nitrates.
> changing environmental conditions such as light & temperature.

Rakshita Singh

NCERT Diagrams for reference

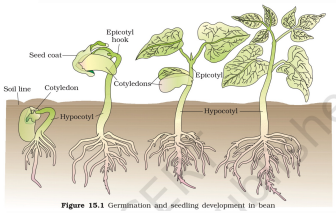


Figure 15.1 Germination and seedling development in bean

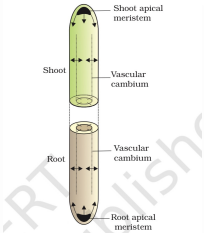


Figure 15.2 Diagrammatic representation of locations of root apical meristem, shoot aplical meristem and vascular cambium. Arrows exhibit the direction of growth of cells and organ

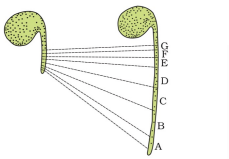


Figure 15.3 Detection of zones of elongation by the parallel line technique. Zones A, B, C, D immediately behind the apex have elongated most.

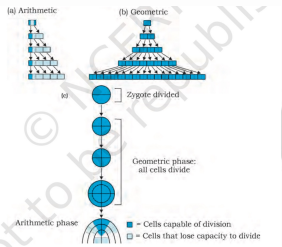


Figure 15.4 Diagrammatic representation of : (a) Arithmetic (b) Geometric growth and (c) Stages during embryo development showing geometric and arithmetic phases

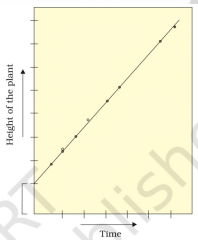


Figure 15.5 Constant linear growth, a plot of length L against time t

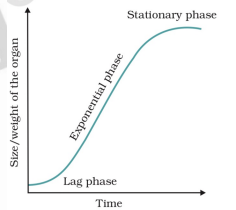


Figure 15.6 An idealised sigmoid growth curve typical of cells in culture, and many higher plants and plant organs

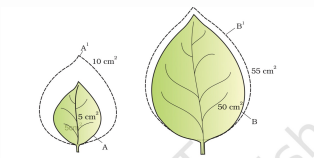


Figure 15.7 Diagrammatic comparison of absolute and relative growth rates. Both leaves A and B have increased their area by 5 cm² in a given time to produce A', B' leaves.

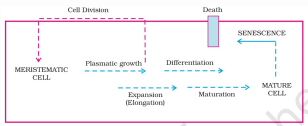


Figure 15.8 Sequence of the developmental process in a plant cell

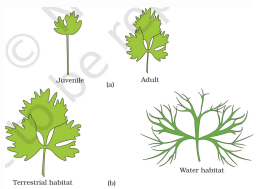


Figure 15.9 Heterophylly in (a) larkspur and (b) buttercup

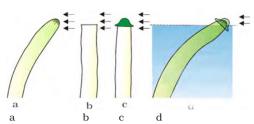


Figure 15.10 Experiment used to demonstrate that tip of the coleoptile is the source of auxin. Arrows indicate direction of light

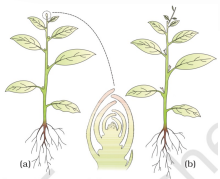


Figure 15.11 Apical dominance in plants : (a) A plant with apical bud intact (b) A plant with apical bud removed Note the growth of lateral buds into branches after decapitation.

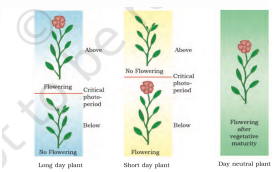


Figure 15.12 Photoperiodism : Long day, short day and day neutral plants

Rakshita Singh

Digestion and Absorption

MAJOR COMPONENTS OF FOOD
- Carbohydrate
- Proteins
- Fats
- Vitamins and minerals (Small quantities)

FOOD PROVIDES
Energy and organic materials for growth & repair of tissues

WATER IS NEEDED FOR?
Metabolic processes & prevents from dehydration

Digestion
Both mechanical and biochemical process in which bio macromolecules are broken down in simple absorbable substance.

DIGESTIVE SYSTEM

Alimentary canal
Begins with mouth, buccalcavity/oralcavity which contains teeth & muscular tongue.

Associated glands

Teeth
NEET 2018

Thecodont
>teeths are embedded in the socket of jaw bone

Diphyodont
>present in majority of mammals
>two sets of teeth in life span

Heterodont
>different types of teeth
~incisor
~canine
~premolar
~molar

Temporary/decidious
For children

Permanent
For adult

$\frac{2123}{2123}$ Dental formula

Hard chewing surface of teeth made up of enamel helps in mastication of food

Muscular tongue
Freely movable, attached to floor by frenulum & upper surface of tongue have projections called as papillae (have taste buds)

Then comes the short pharynx which is common passage for food & air

Air (trachea or wind pipe)
Epiglottis prevents entry of food into wind pipe during swallowing

Food(oesophagus->thin & long)
Post. passing through neck,thorax,diaphragm
Opens into stomach via muscular gaestro-oesophageal sphincter

Stomach is a J shaped organ at upper left portion of abdominal cavity

Contains 4 major portion cardiac, fundic, body (main central) & pyloric (opens into small intestine).

Pyloric sphincter guards the opening of stomach into 1st part of small intestine

Then comes the small intestine

3 parts:- duodenum (c shaped), middle jejunum(long coiled) , ileum (highly coiled) → NEET 2020, 22

Ileum opens into large intestine

Caecum

(Small blind sac which hosts symbiotic microorganisms)

Vermiform appendix(narrow finger like tubular projection) arises from here which is vestigial

Colon

1. Ascending
2. Transverse
3. Descending
4. Sigmoid

Rectum

And then it leads finally to anus

Walls of alimentary canal

All 4 layers show modification in different parts of alimentary canal

Serosa

> outermost layer, made of thin mesothelium with some connective tissue

Mesothelium is the epithelium of visceral organs.

Muscularis

> inner circular
> oblique in some regions
> outer longitudinal
> made of smooth muscles

Sub mucosa

> with nerves,blood,lymph vessels
> made of loose connective tissue

Brunner's glands (2019)

Mucosa

Innermost
Lines the lumen of canal
It contains irregular folds in stomach & villi in small intestine.

NEET 2019

Villi have no. Of capillaries & large lymph vessels called lacteals.
*mucosal epi. has goblet cells which secrete mucus & helps in lubrication
*mucosa forms glands in stomach i.e. gastric glands
*and crypts b/w base of villi in intestine is called crypts of lieberkuhn
*duodenum glands are present in submucosa

NEET 2017

MICROVILLI

Formed by cells lining villi.
Gives brush border appearance and increase surface area.

Digestive glands

Salivary glands

Three pairs:-
> parotid
> sub maxillary
> submandibular
> sublingual

Outside the buccal cavity & secrete salivary juice.

Liver

Largest gland(1.2-1.5kg)
Just below diaphragm (abdominal cavity)
It have 2 hepatic lobes or lobules (str. & functional unit)

It have hepatic cells in form of cords & covered by thin connective tissue sheath c/a glisson's capsule.
Secrete bile in hepatic duct which is stored in gall bladder which is thin muscular sac.
Cystic duct from gall bladder joins with hepatic duct to form common bile duct and which further joins with pancreatic duct to form hepatopancreatic duct which enters duodenum guarded via sphincter of oddi.

NEET2016

Pancreas

Compound gland, situated b/w limbs of duodenum. Its endocrine part releases alkaline pancreatic juice containing enzymes & endocrine part secretes hormones, insulin, glucagon.

NEET 2017

DIGESTION OF FOOD

It is both mechanical & biochemical

In buccal cavity

Mastication of food with teeth & tongue, facilitation of swallowing. Digestion is initiated.

Saliva contains electrolytes (Na+, K+ , Cl-, HCO3-), Enzymes, salivary amylase, lysozyme (antibacterial agent and prevents infection)

Starch —(Salivary Amylase, pH 6.8)→ Maltose

Gastric glands

Mucus neck cells secrete mucus

Peptic/chief cell secrete proenzyme pepsinogen

Parietal/oxyntic cell secrete HCl & castle intrinsic factor (needed for absorption of vit B12)

Food in stomach is stored for 4-5 hours & then called chyme. Food is mixed with acidic gastric juice via churning movement of its muscular walls.

Pepsinogen + HCl ⟶ Pepsin(active proteolytic Enzyme)

Proteins —(Pepsin)→ Proteoses + peptones

Mucus & bicarbonate provides lubrication & protection of mucosal epithelium from excorication (pH of stomach- 1.8)

NEET 2016

Rennin (proteolytic enzyme) in infants help in milk proteins digestion. Small amount of lipase also secreted by gastric glands but no amylase.

Small intestine

Various types of movements by muscularis & mixes bile juice, pancreatic juice & secretion from small intestine with the food.

The pancreatic juice contains inactive enzymes, trypsinogen, chymotrypsinogen, procarboxypeptidase, amylase, lipase, nucleases

Trypsinogen in presence of entrokinase (by intestinal mucosa) is converted into trypsin which further activates other enzymes

NEET 2020

Bile juice contains bile pigments bilirubin & biliverdin, bile salts, cholesterol, phospholipids, no enzymes!. It activates lipases & perform emulsification of fat in small micelles.

Intestinal juice:- mucosal epithelium have goblet cells and forms the succus entericus or intestinal juice. It have disaccharidases, dipeptidases, lipases, nucleosidases, mucus & bicarbonate (pancreas) protect intestinal mucosa & provide alkaline medium (pH 1.8) for enzymes. Submucosal brunners gland also help in this.

Proteins / Peptones / Proteoses —(Trypsin/Chymotrypsin, Carboxypeptidase)→ Dipeptides

Polysaccharides (starch) —(Amylase)→ Disaccharides

Fats —(Lipases)→ Diglycerides ⟶ Monoglycerides

Nucleic acids —(Nucleases)→ Nucleotides ⟶ Nucleosides

Dipeptides —(Dipeptidases)→ Amino acids

Maltose —(Maltase)→ Glucose + Glucose

Lactose —(Lactase)→ Glucose + Galactose

Sucrose —(Sucrase)→ Glucose + Fructose

Nucleotides —(Nucleotidases)→ Nucleosides —(Nucleosidases)→ Sugars + Bases

Di and Monoglycerides —(Lipases)→ Fatty acids + Glycerol

The food is absorbed in jejunum & ileum. And undigested & unabsorbed food is sent to large intestine. Large intestine doesn't have significant digestive activity hence absorption of water, minerals & drugs take place. It also secrete mucus which adheres waste for easy passage.

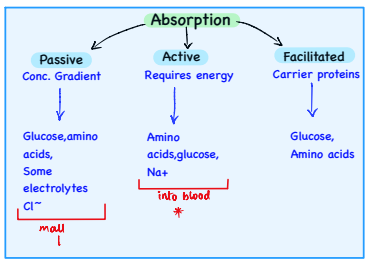
Regulation

It is under both neural & hormonal control.

*Sight, smell presence of food secretes saliva
*gastric and intestinal tract are under neural signals
*muscular activities of diff. Parts are under neural mechanism (local or by CNS
*digestive juices[hormonal control]
*local hormones=gastric and intestinal mucosa

ABSORPTION OF DIGESTED PRODUCTS

End products of digestion are absorbed into blood/lymph via intestinal mucosa. Maximum absorption takes place in small intestine.



*Transport of water depends on osmotic gradient
*fatty acids and glycerol (insoluble) can't be absorbed into blood
*incorporated into small droplets c/a micelles
*micelles in intestinal mucosa reformed into chylomicrons (very small protein coated fat globules) which are further transported into lacteals via villi which further deport them into blood stream

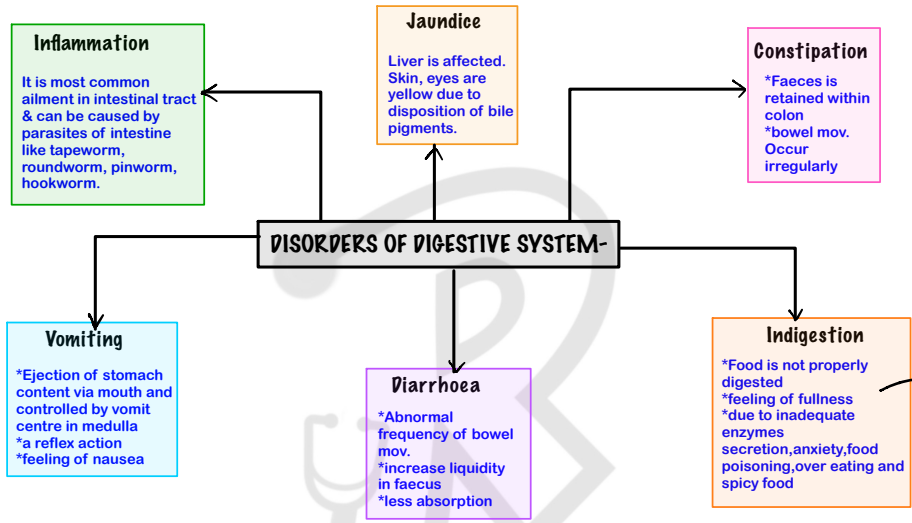
NEET 13, 21

Table 16.1 The Summary of Absorption in Different Parts of Digestive System

Mouth	Stomach	Small Intestine	Large Intestine
Certain drugs coming in contact with the mucosa of mouth and lower side of the tongue are absorbed into the blood capillaries lining them.	Absorption of water, simple sugars, and alcohol etc. takes place.	Principal organ for absorption of nutrients. The digestion is completed here and the final products of digestion such as glucose, fructose, fatty acids, glycerol and amino acids are absorbed through the mucosa into the blood stream and lymph.	Absorption of water, some minerals and drugs takes place.

ASSIMILATION The absorbed substance reaches tissues which utilises them

The rectum produces neural reflex & thus egestion of faeces through anal opening (defaecation) takes place. It is a voluntary process carried out by mass peristalsis movement.



Marasmus - deficiency of both proteins and Calories - AIPNT 2009

education

NCERT diagrams for reference

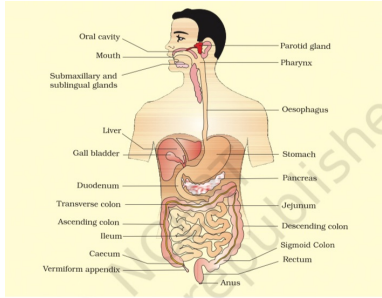


Figure 16.1 The human digestive system

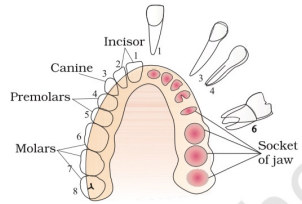


Figure 16.2 Arrangement of different types of teeth in the jaws on one side and the sockets on the other side

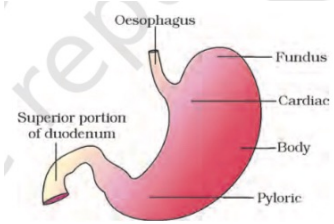


Figure 16.3 Anatomical regions of human stomach

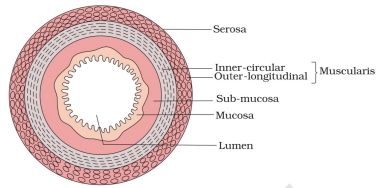


Figure 16.4 Diagrammatic representation of transverse section of gut

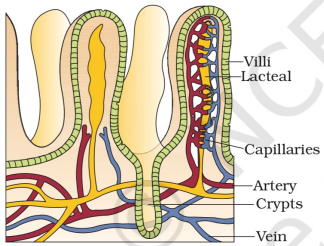


Figure 16.5 A section of small intestinal mucosa showing villi

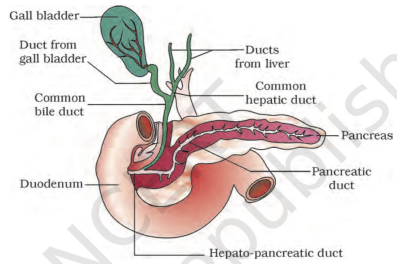


Figure 16.6 The duct systems of liver, gall bladder and pancreas

Calorific Value of Protein, Carbohydrate and Fat
(Boxed item – Not for evaluation)

The energy requirements of animals, and the energy content of food, are expressed in terms of measure of heat energy because heat is the ultimate form of all energies. This is often measured to as calorie (cal) or joule (J), which is the amount of heat energy required to raise the temperature of 1 g of water by 1 °C. Since this value is tiny amount of energy, physiologists commonly use kilocalorie (kcal) or kilo joule (kJ). One kilo calorie is the amount of energy required to raise the temperature of 1 kg of water by 1 °C. Nutritionists, traditionally refer to kcal as the Calorie or Joule (always capitalised). The amount of heat liberated from complete combustion of 1 g food in a bomb calorimeter (a closed metal chamber filled with O_2) is its gross calorific or gross energy value. The actual amount of energy combustion of 1 g of food is the physiologic value of food. Gross calorific values of carbohydrates, proteins and fats are 4.1 kcal/g, 5.65 kcal/g and 9.45 kcal/g, respectively, whereas their physiologic values are 4.0 kcal/g, 4.0 kcal/g and 9.0 kcal/g, respectively.

PEM

Dietary deficiencies of proteins and total food calories are widespread in many underdeveloped countries of South and South-east Asia, South America, and West and Central Africa. **Protein-energy malnutrition (PEM)** may affect large sections of the population during drought, famine and political turmoil. This happened in Bangladesh during the liberation war and in Ethiopia during the severe drought in mid-eighties. PEM affects infants and children to produce Marasmus and Kwashiorkar.

Marasmus is produced by a simultaneous deficiency of proteins and calories. It is found in infants less than a year in age, if mother's milk is replaced too early by other foods which are poor in both proteins and caloric value. This often happens if the mother has second pregnancy or childbirth when the older infant is still too young. In Marasmus, protein deficiency impairs growth and replacement of tissue proteins; extreme emaciation of the body and thinning of limbs results, the skin becomes dry, thin and wrinkled. Growth rate and body weight decline considerably. Even growth and development of brain and mental faculties are impaired.

Kwashiorkar is produced by protein deficiency unaccompanied by calorie deficiency. It results from the replacement of mother's milk by a high calorie-low protein diet in a child more than one year in age. Like marasmus, kwashiorkor shows wasting of muscles, thinning of limbs, failure of growth and brain development. But unlike marasmus, some fat is still left under the skin; moreover, extensive oedema and swelling of body parts are seen.

Breathing and exchange of gases

Process of exchange of O_2 from the atmosphere with CO_2 produced by the cells is called breathing/ respiration (physical, chemical & biological process).

Respiratory organs

- Lower invertebrates like sponges, coelenterates, flatworms breath over their entire body surface.
- Earthworms use their moist cuticle & insects have a network of tubes (tracheal tubes) to transport atmospheric air within the body.
- Aquatic arthropods (prawns/ crustachians) and molluscs use vascularised structures called gills (branchial respiration)
- Vascularised bags called lungs (pulmonary respiration) are use by terrestrial forms.
- Among vertebrates fishes use gills- amphibia, reptilia, birds, mammals use lungs. Frogs can respire through their skin (cutaneous respiration)

HUMAN RESPIRATORY SYSTEM

External nostrils —> nasal passage —> nasal chamber —> pharynx (nasopharynx) —> larynx region in trachea —> trachea divides at 5th vertebra (thoracic) into right & left primary bronchi —> secondary & tertiary bronchi & bronchioles—> terminal bronchioles (thin) —> irregular walled vascularised bag like structure called alveoli (the branching network of bronchi, bronchioles & alveoli comprise the lungs)

- Larynx is a cartilaginous box helps in sound production & hence called the sound box.
- Trachea primary, secondary, tertiary bronchi and initial bronchioles are supported by incomplete cartilaginous rings. — NEET 2013
- We have 2 lungs - double layered called as pleural membrane with pleural fluid filled b/w them. It reduces friction on the lung surface the outer pleural membrane is in contact with the thoracic lining whereas the inner layer is in contact with the lung surface. — AIPMT2005

Respiratory system

CONDUCTING PART

(External nostrils to terminal bronchioles)

> Conducts atmospheric air to alveoli
> clears foreign particles
> humidifies air
> brings air to body temperature

RESPIRATORY/ EXCHANGE PART

(Alveoli & their ducts)

> site of actual diffusion of O_2 & CO_2 b/w blood & atmospheric air.

- Lungs are situated in the thoracic chamber which is an anatomically air tight chamber.
- Any change in the volume of the thoracic cavity will be reflected in lung (pulmonary) cavity. It is very important as we cannot directly alter the pulmonary volume.

Steps of respiration

- Breathing (intake of O_2 & exhalation of CO_2)
- Diffusion of gases across alveolar membrane
- Transport of gases by the blood
- Diffusion of gases b/w blood & tissues.
- Utilisation of O_2 by cells in deriving energy and release of CO_2 (cellular respiration)

Mechanism of breathing

Pressure gradient b/w lungs & atmosphere

Inspiration

1) Atmospheric air is moved in
2) there is a negative pressure in the lungs with respect to atmospheric pressure.
3) diaphragm contracts (increases volume of anterio posterior axis)
4) external intercostal muscles contract & ribs/ sternum moves upwards which increases volume of the thoracic chamber in the dorso-ventral axis.
5) intrapulmonary pressure is decreased.

NEET 2019

We have ability to increase the strength of breathing with the help of additional muscles in abdomen. Healthy man breaths 12-16 times per minute. The volume of air involved in breathing movements can be estimated by using spirometer helps in clinical assessment of pulmonary functions.

Expiration

> alveolar air is released out.
> intrapulmonary pressure is higher than the atmospheric pressure.
> relaxation of diaphragm and the intercostal muscle return to their original position & reduce the thoracic volume.
> intrapulmonary pressure is increased
> causes expulsion of air from the lungs.

Respiratory volumes & capacities

TIDAL VOLUME(TV)- Volume of air inspired or expired during a normal respiration. It is approx 500ml. i.e. healthy man can inspire or expire approximately 6000 to 8000 ml per minute.

INSPIRATORY RESERVE VOLUME (IRV)- Additional volume of air, a person can inspire by a forcible inspiration. This averages 2500 ml to 3000 ml.

EXPIRATORY RESERVE VOLUME (ERV)- Additional volume of air a person can expire forcefully. This averages 1000ml to 1100ml.

RESIDUAL VOLUME (RV)- Volume of air remaining in lungs even after forceful expiration. This averages 1100 to 1200ml.

INSPIRATORY CAPACITY (IC)- Total volume of air a person can inspire after a normal expiration. Sum of tidal volume and inspiratory reserve volume. (TV+IRV).

EXPIRATORY CAPACITY (EC)- Total volume of air a person can expire after a normal inspiration. Sum of total tidal volume & Expiratory reserve volume (TV+ERV).

FUNCTIONAL RESIDUAL CAPACITY (FRC)- volume of air that will remain in lungs after a normal expiration. This includes ERV+RV.

VITAL CAPACITY (VC)- Maximum volume of air a person can breath in or out after a forced expiration/ inhalation. Includes ERV+TV+IRV.

TOTAL LUNG CAPACITY- Total volume of air accomodated in the lungs at the end of a forced inspiration. Includes RV, ERV, TV, IRV or VC+RV

AIPMT (2009)

Rakshita Singh

Exchange of gases

It is based on pressure and concentration gradient.
FACTORS RESPONSIBLE- solubility of gases, thickness of membrane.

AIPMT 2011

Pressure contributed by an individual gas in a mixture of gases is known as partial pressure and is denoted as pO2 & pCO2 for O2 & CO2 respectively.

As the solubility of CO2 is 20-25 times higher than that of O2, the amount of CO2 that can diffuse through the diffusion membrane per unit difference in partial pressure is much higher compared to that of O2.

DIFFUSION MEMBRANE IS MADE OF 3 LAYERS

- Thin squamous epithelium of alveoli
- Endothelium of alveolar capillaries
- Basement substance b/w them

Its total thickness is less than 1mm. Hence every condition is favourable for respiration in our body.

Transport of gases

Transport of O2

Oxygen - 97% by RBC + 3% by Plasma

Oxygen bind with Hb to form oxyhaemoglobin (reversible reaction). Then each Hb molecule carries 4 O2 molecules.
FACTORS RESPONSIBLE FOR BINDING OF Hb WITH O2:
pO2, pCO2, hydrogen ion concentration, temperature.

Oxygen dissociation curve is sigmoid in shape (graph b/w % saturation of Hb with O2 against O2.

Factors favourable for the formation of oxyhemoglobin-
In alveoli high pO2, less pCo2, less H+, less temp.
Factors responsible for breaking of HbO2-
In tissues less pO2, high pCO2, High H+, high temperature.
Every 100ml of oxygenated blood can deliver around 5ml of O2 to tissues.

Transport of CO2

NEET 2014
CO2 - 70% by bicarbonate + 20-25% by RBC + 7% By plasma

CO2 carried by Hb (20-25%) thus carbamino haemoglobin is formed. (AIPMT 2010)

Conditions for formation of carbaminohaemoglobin - high PCO2, less pO2 in tissues.
Conditions for dissociation of Carbaminohaemoglobin - less pCO2, High pO2 in alveoli.
RBC Contain a very high concentration of enzyme carbonic anhydrase and some quantity in plasma too. Hence the following reaction takes place.

$$CO_2 + H_2O \xleftrightarrow[\text{anhydrase}]{\text{Carbonic}} H_2CO_3 \xleftrightarrow[\text{anhydrase}]{\text{Carbonic}} HCO_3^- + H^+$$

At tissue the reaction forward in right direction and at alveoli reaction forward in opposite direction.
Every 100ml of deoxygenated blood delivers approximately 4ml of CO2 to the alveoli.

Regulation of Respiration

Performed by neural system
Respiratory rythm centre present in the medulla is responsible for the regulation.
Another centre present in the pons region of the brain called pneumotaxic centre can moderate the functions of the respiratory rythm.
Neural signal from this centre can reduce the duration of inspiration and thereby alter the respiratory rate.
A chemosensitive area is situated adjacent to the rythm centre which is highly sensitive to CO2 and H+ ion increase in these substance can activate this center which in turn can signal the rythm centre to make necessary adjustment in the respiratory process by which these substance can be eliminated.
Receptors associated with aortic arch and carotid artery also recognise changes in CO2 & H+ conc. And send necessary signals to the rhythm centre for remedial actions the role of oxygen in the regulation of respiratory rhythm is quite insignificant.

Raksha Singh

Disorders of respiratory system

Asthama

Difficulty in breathing causing wheeziness due to inflammation of bronchi & bronchioles.

Emphysema

Chronic (cannot be easily cured) disorder in which alveolar walls are damaged due to which respiratory surface is decreased. Reason is cigarette smoking.

AIPMT 2015

Occupational respiratory disorder

In stone breaking industry, so much dust is produced, long exposure can give rise to inflammation leading to fibrosis (proliferation of fibrous tissue) and causes serious lung damage.
Workers in such industries should wear protective masks.

NCERT Diagrams for reference

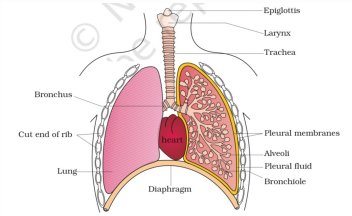


Figure 17.1 Diagrammatic view of human respiratory system (Sectional view of the left lung is also shown)

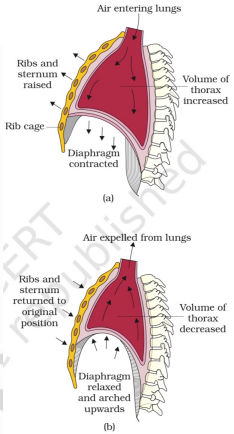


Figure 17.2 Mechanism of breathing showing : (a) inspiration (b) expiration

TABLE 17.1 Partial Pressures (in mm Hg) of Oxygen and Carbon dioxide at Different Parts Involved in Diffusion in Comparison to those in Atmosphere

Respiratory Gas	Atmospheric Air	Alveoli	Blood (Deoxygenated)	Blood (Oxygenated)	Tissues
O_2	159	104	40	95	40
CO_2	0.3	40	45	40	45

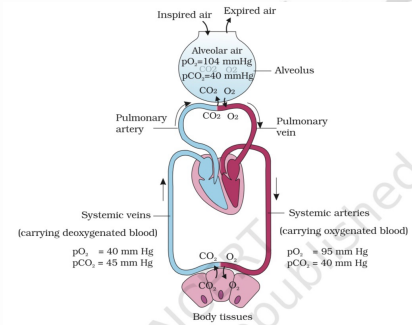


Figure 17.3 Diagrammatic representation of exchange of gases at the alveolus and the body tissues with blood and transport of oxygen and carbon dioxide

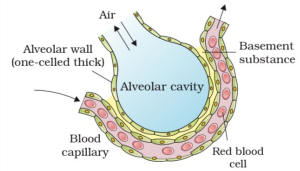


Figure 17.4 A Diagram of a section of an alveolus with a pulmonary capillary.

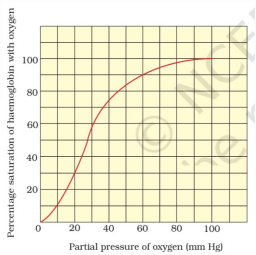


Figure 17.5 Oxygen dissociation curve

Body fluids and circulation

Simple organisms like sponges and coelenterates circulate water from their surroundings through their body cavities to facilitate the cells to exchange these substances.

Blood

(Fluid matrix + plasma + formed elements)

Plasma

Straw coloured, viscous fluid constituting nearly 55% of blood. Plasma = 90-92% water + 6-8% proteins.
Fibrinogen (for blood clotting), globulin (primary defense mechanism), albumin (help in osmotic balance) are major proteins.
Plasma also contain small amount of minerals like Na+, Ca2+, Mg2+, HCO3-, Cl-, etc. Glucose, amino acids, lipids are also present. 13 clotting factors are also present in an inactive form. Plasma without clotting factors is called serum. NEET 2016

Formed elements

Constitute 45% of blood

Erythrocytes/ RBC

Most abundant of all cells in blood.
Healthy man have 5 million RBC Per mm3 of blood.
Formed in red bone marrow. They are devoid of nucleus, biconcave in shape, have coloured protein (complex) called haemoglobin. Healthy individual have 12-16 gm of haemoglobin in every 100ml of blood. Life span of 120 days. They are destroyed in spleen (graveyard of RBC).

Thrombocytes/platelets

Cell fragments produced by megakaryocytes (special cells in the bone marrow).
1,500,00- 3,500,00 platelets per mm3 of blood.
Release variety of substance involved in clotting or coagulation of blood.

Leucocytes/ WBC

Colourless, nucleated (6000-8000 per mm3 of blood), short lived.

GRANULOCYTES

- **Neutrophils** — Most abundant among WBC (60-65%) phagocytic cell
- **Eosinophil** — Resist infections and associated with allergic reaction
- **Basophil** — Least (0.5-1%) Secrete histamine, serotonin, heparin & are involved in inflammatory reaction.

AGRANULOCYTES

- **Lymphocytes** — Involved in immune response of body.
  - B-Lymphocytes
  - T-Lymphocytes (First affected in aids)
- **Monocyte** — Phagocytic cell

BLOOD GROUPS

ABO grouping

Based on presence or absence of 2 surface antigens (chemicals that can induce immune response) on RBC namely A & B. Similarly, the plasma of different individuals contain 2 natural antibodies. (Proteins produced in response to antigens). During the blood transfusion if wrong blood is transferred then clumping (destruction of RBC) may take place.

Table 18.1 Blood Groups and Donor Compatibility

Blood Group	Antigens on RBCs	Antibodies in Plasma	Donor's Group
A	A	anti-B	A, O
B	B	anti-A	B, O
AB	A, B	nil	AB, A, B, O
O	nil	anti-A, B	O

AIPMT 2014

Rh- grouping

Rh antigen similar to one present in Rhesus Monkey is also observed on the surface of RBC of nearly 80% humans such individuals are called Rh positive and rest are called as Rh -ve.
If Rh+ve blood is transferred to Rh -ve person then production of antibodies against antigen take place (hence we need to take care of it)
Incompatibility case of Rh -ve blood of a pregnant mother with Rh +ve blood of foetus.
The first child can be delivered successfully but during delivery of first child there is possibility of exposure-of maternal blood to small amount of Rh +ve blood from foetus. In case of her further pregnancies the Rh antibodies from the mother can leak into the blood of the foetus and destroy the foetal RBC. This can cause anaemia, jaundice to baby.
This condition is called as erythroblastosis foetalis. It can be avoided by providing anti Rh- antibodies to the mother after delivery of 1st child.

Rakshita Singh

Coagulation of blood

Clot is formed mainly of a network of threads called fibrins in which dead & damaged formed elements of blood are trapped.
Fibrins are formed by the conversion of inactive fibrinogens in the plasma by the enzyme thrombin (formed from prothrombin). Thrombokinase enzyme complex is required for above reaction. Which is formed by cascade process involving a no. Of factors present in plasma in inactive state.
Ca2+ & Vit K are very important for clotting.

Lymph (tissue fluid)

Colourless fluid containing lymphocytes which are responsible for immune responses. Lymph is also an important carrier for nutrients, hormones, fats are absorbed through lymph in lacteals present in intestinal villi.
As blood passes in blood vessels —> many substance are left in tissue, cell —> tissue fluid/ interstitial fluid —> exchange of nutrient, gases occur by this fluid —> lymphatic system takes this fluid and deliver it to major veins —> now it is known as lymph.

Circulatory pathways

CIRCULATORY PATTERNS

OPEN
> blood is pumped into open/ free spaces called sinuses.
> Eg- arthropods, molluscs

CLOSED
> blood flow is more advantageous as the flow of fluid can be more precisely regulated.
> Eg- annelida, chordates.

Fishes (single circulation)
Deoxygenated blood is pumped by heart —> through gills oxygenated blood is taken to all body parts —> deoxygenated blood is collected & transferred to heart.

Amphibian/ reptiles (incomplete double circulation)
Oxygenated blood from left atria & deoxygenated blood from right atria goes into single ventricle & mixed blood is circulated.
Crocodile have 4 chambered heart in reptiles (exception).

Human circulatory system

Heart

Mesodermal in origin, size equal to clenched fist. Protected by double walled membranous bag, pericardium enclosing pericardial fluid. Atria are smaller than ventricles.

Atria's are separated by thin inter atrail septum and ventricles are separated by thick interventricular septum. Atrium and ventricles are separated by atrioventricular septum.

Right ventricle and auricle are joined with 3 muscular flaps or cusps, tricuspid valve and bicuspid or mitral valve guards opening b/w left atrium & ventricle.

The opening of the right & left ventricles into the pulmonary artery & aorta respectively are provided with semilunar valve.
Heart is made of cardiac muscle & walls of ventricles are thicker than that of aorta.

Nerve impulse initiation and conduction in heart

A specialised cardiac musculature called the nodal tissue is present in the heart. A patch of this tissue is present in the upper right corner of the right atrium called sino-atrial node (SAN). Another mass of this tissue is seen in the lower left corner of the right atrium close to atrioventricular septum called the atrioventricular node (AVN).

Bundle of nodal fibres (AV bundle) continues from AVN passes through AVS & emerge on the top of interventricular septum & divide into right & left bundle. Branches give rise to minute fibres throughout the ventricular musculation and are called as purkinje fibres. → the fibres are in bundles called Bundle of His – AIPMT 2011

The nodal musculature has ability to generate action potential without external stimuli i.e. autoexcitable. No. Of action potential generated in 1 minute vary at different parts of the nodal system. SAN is also known as pace maker which generates action potential 70-75 per minute which is responsible for normal heart beat rate i.e. 72 times per minute.

CARDIAC CYCLE

First the atria and ventricles are in joint diastole that is relaxed all tri/bicuspid valves are open. (Semilunar valves are closed)
SAN generates action potential which tells atria to undergo contraction (atrial systole) hence flow of blood in ventricles increases by 30%.

AVN & AV bundles transfer the potential to ventricle. This bundle of his transfers it to whole ventricular musculature.
Because of this the ventricles undergo contraction (ventricular systole) the atria undergo relaxation (diastole) coinciding with ventricular systole.
Joint systole is never possible.

The ventricles now relax (ventricular diastole) and because of it semilunar valve get closed and bi/ tricuspid valves get opened by pressure of blood from atria. The blood once again move freely into ventricles and the process continues.

Rakshita Singh

This sequential event in the heart which is clinically repeated is called the cardiac cycle & it consists of systole & diastole of both atria and ventricles.
Duration of a cardiac cycle is 0.8 sec.

STROKE VOLUME-
During a cardiac cycle each ventricle pumps 70ml of blood which is called as stroke volume.

CARDIAC OUTPUT-
Stroke volume x heartrate / volume pumped by ventricle in 1 minute.
For healthy person it is 5L.

The cardiac output of an athlete will be much higher than that of an ordinary man.
During each cardiac cycle two prominent sound are produced.
1) LUB (closure of tri/bicuspid valves)
2) DUB (closure of semilunar valve)
These sounds are of clinical diagnostic significance which can be easily heard by stethoscope.

ELECTROCARDIOGRAPH (ECG)

- It is a machine & is used to obtain a electrocardiogram. ECG is a graphical representation of electrical activity of the heart during a cardiac cycle.
- Patient is connected to the machine with 3 electrical leads (2 at wrists and third at left ankle) for a detailed evaluation multiple leads are attached to the chest region.
- P wave represents the electrical excitation (or depolarisation) of atria (contraction of atria).
  QRS complex represents the depolarisation of ventricles (ventricular contraction)
  Q marks the beginning of systole.
- T wave represents the repolarisation of ventricles (i.e. return to normal state)
  The end of T wave marks the end of systole.
  One can determine heart rate by counting no. Of QRS complex.

NEET 2020

Double circulation

A unique vascular connection exists b/w the digestive tract and liver called the hepatic portal system. The hepatic portal vein carries blood from intestine to the liver before it is delivered to the systemic circulation. A special coronary system of blood vessels is present in our body exclusively for the circulation of blood to and from the cardiac musculature.

HISTOLOGY OF BLOOD VESSELS

- Tunica intima (inner lining of squamous endothelium)
- Tunica media (middle layer of smooth muscles & elastic fibres) It is thin in veins.
- Tunica externa (outer layer of fibrous connective tissue with collagen fibres)

Regulation of cardiac activity

Human heart is myogenic because it is auto regulated by special muscles (nodal tissue). A special neurL centre in the medulla oblongata can moderate the cardiac function through autonomic nervous system.
Neural signals from sympathetic nerves (part of ANS)) can increase heart rate, the strength of ventricular contraction and these by cardiac output. Parasympathetic neural signals (another component of ANS) decrease the rate of heart beat, speed of conduction of action potential and thereby the cardiac output.
Adrenal medullary hormones can also increase the cardiac activity.

DISORDERS OF CIRCULATORY SYSTEM

High blood pressure/ hypertension

BI higher than normal (120/80 mmHg) 120 is the systolic or pumping pressure & 80 is the diastolic or resting pressure. If it reaches to 140/90 or higher then it is known as high Bp & can cause heart diseases or can affect brain/kidney.

Coronary artery disease(CAD) or artherosclerosis

Caused due to deposit of Ca, fat, cholesterol & fibrous tissue in the vessel causing lumen of arteries narrower.

Angina/angina pectoris

Acute chest pain when there is not enough supply of O2 to heart muscles. More common in middle aged or elderly people.
Occurs due to conditions which affect blood flow.

Heart failure

Heart is not pumping efficiently to meet the body requirements of O2.
Sometimes called congestive heart failure because congestion of lungs is one of the main symptoms of this disease.
CARDIAC ARREST - heart stops beating
HEART ATTACK - heart muscle is suddenly damaged by an inadequate blood supply.

Rakshita Singh

NCERT Diagrams for reference

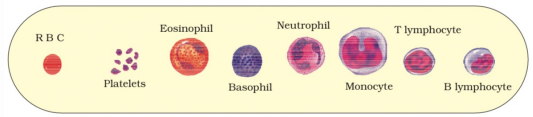


Figure 18.1 Diagrammatic representation of formed elements in blood

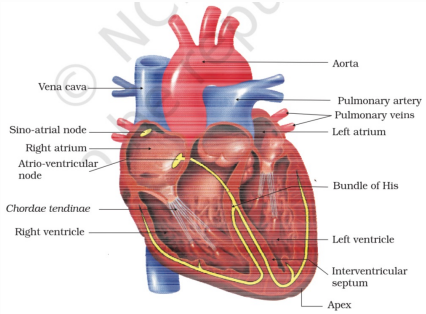


Figure 18.2 Section of a human heart

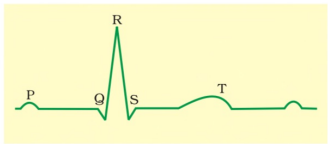


Figure 18.3 Diagrammatic presentation of a standard ECG

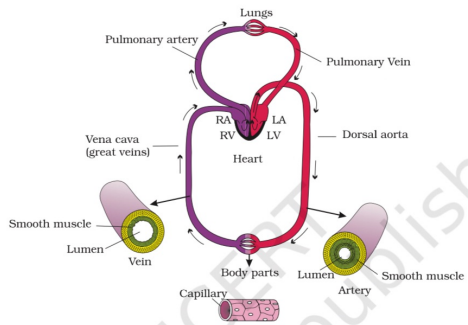


Figure 18.4 Schematic plan of blood circulation in human

Excretory products & their elimination

Ammonia (most toxic and need high amounts of water for excretion), urea, uric acid (least toxic) are the major forms of nitrogenous wastes excreted by the animals.

AIPMT 2012

Many bony fishes, aquatic amphibians & aquatic insects are ammonotelix in nature in which ammonium ion is released from body surface or gill surface kidneys do not play a significant role in its removal.

AIPMT 2011, 2012

Mammals, many terrestrial amphibians & marine fishes mainly excrete urea & are called ureotelic animals. Ammonia in liver by ornithine cycle is converted to urea.

Reptiles, birds, land snails & insects secrete nitrogenous waste as uric acid in the form of pellet of paste and are called uricotelic animals.

Protonephridia/flame cells are excretory structures in platyhelmenthis (eg- planaria), rotifers, some annelids and cephalochordates (amphioxus). Protonephridia are primarily concerned with ionic and fluid volume regulation i.e. osmoregulation.

Nephridia are the tubular excretory structures of earthworm & other annelids. Nephridia help to remove N2 waste & maintain osmoregulation.

Malphigian tubules are present in insects (cockroach) which help in the removal of N2 waste & osmoregulation.

Antennal glands or green glands perform the excretory function in crustaceans like prawns.

Human excretory system

2 kidneys + 2 ureter + urinary bladder + urethra

NEET 2013

Kidneys are present b/w levels of last thoracic & lumbar vertebrae close to dorsal inner wall of the abdominal cavity.
Parameters -> 10-12 cm in length, 5-7 cm width, 2-3 cm in thickness , avg wt. - 120-170gm.
Towards the centre of the inner concave side of kidney is a notch called hilum through which ureter, blood vessels and nerves enter.

Inner to hilum is a broad funnel shaped space called the renal pelvis with the projections called calyces. Outer layer of kidney is tough capsule & 2 zone of internal kidney- outer cortex & inner medulla. Medulla is divided into few conical masses (medullary pyramids) projecting into calyces.

The cortex extends in b/w the medullary pyramids as renal columns called columns of bertini.
Each kidney have 1 million nephron (functional unit).
Each nephron have 2 parts (glomerulus & renal tubule)

GLOMERULUS- tuft of capillaries formed by afferent arteriole (a fine branch of renal artery) blood is taken away by efferent arteriole.
RENAL TUBULE- begins with the cup. Bowman's capsule (encloses glomerulus)
Glomerulus and bowmans capsule forms malphigian body or renal corpuscle.

The tubules further grows to form a highly coiled network (proximal convulated tubule/ PCT) further a hairpin shaped henle loop is present. Ascending limb continues to form distal convulated tubule (DCT). DCT's of many nephron open into a straight tube called collecting duct, many of which converge and open into the renal pelvis through medullary pyramids in the calyces.
Malphigian corpuscle, PCT & DCT are situated in cortical region while henle loop dips into the medulla.

Nephrons are of 2 types

CORTICAL
(Major nephrons)
The henle loop is short

JUXTRA MEDULLARY
(Minor in no.)
Henle loop is long

The capillary network of efferent arterioles around renal tubule is called peritubular capillaries. The vessel which runs parallel to henle loop is known as vasa recta (U- shaped). Vasa recta is absent or highly reduced in cortical nephrons.

Kalu Singh

URINE FORMATION

Glomerular filtration

On an average kidney filters 1100-1200ml of blood per minute which constitute 1/5th of the blood pumped by heart in one minute.
The glomerular capillary blood pressure causes filtration of blood through 3 layers i.e. endothelium of glomerular blood vessels, the epithelium of bowmans capsule & a basement memb. b/w thse 2 layers.
There are some slits or slip pores in b/w the podocyte cells (epithelial cells of bowmans capsule)
All the components of plasma except proteins pass onto the lumen of bowmans capsule hence it is known as ultra filtration.
GLOMERULAR FILTRATION RATE (GFR) - amount of filtrate formed by the kidneys per minute for healthy individual it is about 125 ml/min i.e. 180l/day.
JUXTA GLOMERULAR APPARATUS- mechanism for regulation of GFR & it is located by cellular modification in the DCT & afferent arteriole joining. A fall in GFR can activate JG cells to release renin which can stimulate the glomerular blood flow & thereby GFR back to normal.

AIPMT 2011

Reabsorption

Filtrate formed is 180l/day but urine generated only 1.5 l per day hence rest all is reabsorbed by renal tubules. It can be performed actively or passively by tubular epithelial cells in different segments.
For eg- glucose, amino acid, Na+ are actively reabsorbed whereas N2 waste are absorbed by passive transport.
Reabsorption of H2O is also passive in initial segments of nephron.

AIPMT 2010

Tubular secretion

Tubular cells secrete substance like H+, K+, NH3 into filtrate as it helps in the maintenance of ionic & acid base balance of body fluids.

FUNCTIONS OF THE TUBULES

Proximal convulated tubule (PCT)

Lined by simple cuboidal brush border epithelium which increases area of absorption. Nearly all essential nutrients, 70-80% electrolytes and water are reabsorbed. It secretes H+, K+, NH3 in the filtrate and Absorption of HCO3- is done.

AIPMT 2012

Henle's loop

Reabsorption is minimum in ascending limb because this region plays important role in maintenance of high osmolarity of medullary interstitial fluid. The descending limb is permeable to water but impermeable to electrolytes. The ascending limb is permeable for electrolyte but impermeable to water hence hypertonic in descending limb & hypotonic in ascending limb.

Distal convulated tubule (DCT)

Conditional reabsorption of Na+ & H2O Takes place. Reabsorption of HCO3- & secretion of H+, K+ & NH3 to maintain pH & Na+, K+ balance in blood.

Collecting duct

Extend from cortex to medulla. Large part of H2O is reabsorbed to produce a concentrated urine, this allows passage of urea (little) into the medullary interstitum to keep up the osmolarity it performs the secretion of H+, K+ ion for maintenance of H+ & ionic balance in blood.

Mechanism of concentration of filtrate (Mammals)

The flow of filtrate in the two limbs of henle loop is in opposite direction and the flow of blood through the two limbs of vasa recta is also in a counter current pattern. The proximity b/w henle loop & vasa recta as well as counter current in them help in maintaining an increasing osmolarity towards the inner medullary interstitium i.e. from 300 mOsmoL-1 in cortex to 1200 mOsmolL-1 in the inner medulla.

Gradient is mainly caused by Nacl & urea. The transport of substance facilitated by the special arrangement of henle loop & vasa recta is called the counter current mechanism.
This helps to maintain a conc. gradient in the medullary interstitium which helps in an easy passage of water from the collecting tubule thereby concentrating the filtrate.
Human kidneys can produce urine nearly 4 times concentrated than the initial filtrate formed.

Rakshita Singh

Regulation of kidney function

Regulated by hormonal feedback mechanisms involving the hypothalamus, JGA & heart (little extent)

AIPMT 2011

Osmoregulators in the body are activated by changes in blood volume, body fluid volume & ionic concentration (for eg- an excessive loss of fluid.
This stimulates hypothalamus to release antidiuretic hormone (ADH) or vasopressin from neurohypophysis ADH facilitates reabsorption from later part of tubules hence prevents diuresis.
Increase in body fluid volume shut the osmoreceptors & suppress ADH release to complete the feedback.

ADH canals affect the kidney function by its constrictory effects on blood vessels. This causes an increase in Bp, an increase in blood pressure can increase the glomerular blood flow & thereby the GFR.

AIPMT 2012

Falling glomerular blood flow/ BP/ GFR can activate the JG cells to release renin which converts angiotensinogen in blood to angiotensin I & angiotensin II.
Angiotensin II (powerful vasoconstrictor) increases glomerular Bp thereby GFR it activates the adrenal cortex to release aldosterone which causes reabsorption of Na^+ & H_2O from the distal parts of tubule. This also increase GFR.
THE MECHANISM IS KNOWN AS RENIN ANGIOTENSIN MECHANISM.

NEET 2020, 22

An increase in blood flow to the atria of heart can cause the release of atrial natriuretic factor (ANF) which causes vasodilation and thereby causes decrease in BP.
ANF mechanism acts as a check on renin angiotensin mechanism.

NEET 2017

Micturation

AIPMT 2009

Urine is stored in urinary bladder until a voluntary signal is given by the central nervous system. This signal is initiated by the stretching of the urinary bladder as it gets filled with urine in response, the stretch receptors on the walls of the bladder send signals to the CNS. The CNS passes on motor messages to initiate the contraction of smooth muscles of the bladder and simultaneous relaxation of the urethral sphincter causing the release of urine. This is known as micturation reflex.
An adult human excretes 1.5L- 1L urine per day. pH of urine is 6 and has a characteristic odour. 25-30 gm of urea is excreted out per day. Analysis of urine helps in clinical diagnosis of many metabolic disorders as well as malfunctioning of the kidney.
Eg- presence of glucose (glycosuria) & ketone bodies (ketonuria) in urine are signs of diabetes mellitus.

NEET 2015

Role of other organs in excretion

Lungs remove 20pml CO_2 per minute and also significant quantity of water.
Liver secretes bile containing bilirubin, biliverdin, cholesterol, degraded steroid hormones, vitamins & drugs. These substance pass through digestive tract.
Sweat & subaceous gland in skin eliminate sweat (water + NaCl + urea + lactic acid) & (sterols, hydrocarbons, water) through sebum.
Small amount of Nitrogenous waste could be eliminated through saliva.

Disorders of excretory system

Uremia

Malfunctioning of kidneys can lead to accumulation of urea in blood which is highly harmful & may lead to kidney failure.
In such patients, urea can be removed by a process called haemodialysis in which blood drained from a convenient artery is pumped into a dialysing unit called artificial kidney after adding an anticoagulant like heparin. The unit contains a coiled cellophane tube surrounded by a fluid (dialysing fluid) having same composition that of plasma except the nitrogenous waste.
The cleared blood is pumped back to the body through a vein after adding anti heparin to it. This method is a boon for thousand of uremic patients all over the world.
Kidney transplantation is the ultimate method in the correction of acute renal (kidney) failures. A functioning kidney is used in transplantation from a donor, preferably a close relative, to minimise its chances of rejection by the immune system of the host.

Renal canaliculi

Stone or insoluble mass of crystallised salts (oxalates) formed within the kidney.

Glomerulonephritis

Inflammation of glomeruli of kidney

Rakshita

NCERT Diagrams for reference

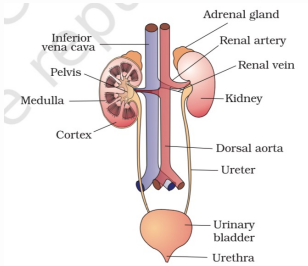


Figure 19.1 Human Urinary system

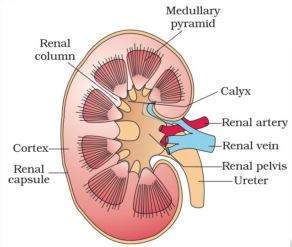


Figure 19.2 Longitudinal section (Diagrammatic) of Kidney

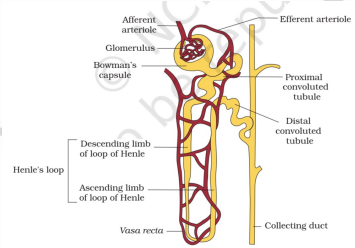


Figure 19.3 A diagrammatic representation of a nephron showing blood vessels, duct and tubule

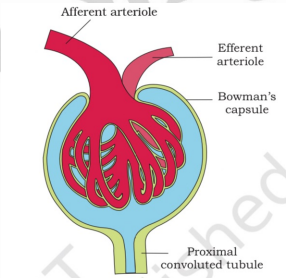


Figure 19.4 Malpighian body (renal corpuscle)

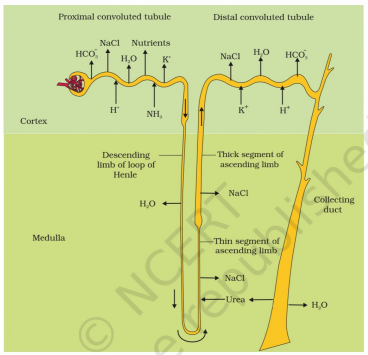


Figure 19.5 Reabsorption and secretion of major substances at different parts of the nephron (Arrows indicate direction of movement of materials.)

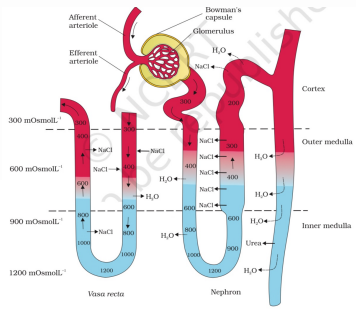


Figure 19.6 Diagrammatic representation of a nephron and *vasa recta* showing counter current mechanisms

Locomotion and Movement

> streaming of protoplasm in the unicellular organisms like amoeba is a simple form of movement.
> in paramaecium cilia helps in movement of food through cytopharynx and in Locomotion as well.
> hydra can use its tentacles for capturing its prey and also use them for locomotion.
> locomotion is generally for search of food,shelter,mate,suitable breeding grounds,favourable climate,escape from enemies. Method of locomotion depend on habitat & demand of situation.

MUSCLE

Flagellar movements help in the swimming of spermatozoa, maintenance of water current in the canal system of sponges and in locomotion of protozoans like euglena.
Muscle is a specialised tissue of mesodermal origin (40-50% body wt. = muscle).
They are excitable,contractile,extensible and elastic.

TYPES OF MOVEMENT

AMOEBOID
Eg-macrophages & leucocytes.
It is effected by pseudopodia formed by streaming of protoplasm.
Cytoskeletal elements like microfilaments are also involved in it.

CILIARY
Occur in internal organs which are lined by ciliated epithelium. Eg-trachea(coordinated), fallopian duct

MUSCULAR
Their contractile property is effectively used for locomotion or movement.
Eg-limbs,jaw, tongue movement.

Locomotion requires a perfect coordinated activity of muscular,skeletal and neural systems.

TYPES OF MUSCLE

SKELETAL
> striated,voluntary (under nervous system)
> primary involved in locomotory action.
> skeletal components of the body.

VISCERAL
> located in the inner walls of hollow visceral organs (alimentary canal/respiratory tract)
> smooth,involuntary,non striated
> assist in transportation.

CARDIAC
> heart muscles, striated, branched and involuntary in nature as the nervous system does not control their activities directly.

STRUCTURE AND MECHANISM OF MUSCLE CONTRACTION

Skeletal muscle is made of a no. Of muscle bundles/fascicle held together by common collagenous connective tissue layer called fascia. Each muscle bundle contains a no. Of muscle fibres. (Synctium => multinucleated)
Plasma membrane ——> sarcolemma
Cytoplasm ——> sarcoplasm
Endoplasmic reticulum ——> sarcoplasmic reticulum (store house of Ca2+)
They have large no. Of parallel arranged filaments called myofibrils or myofilaments.
Striated appearance is due to the distribution pattern of two important proteins -> ACTIN & MYOSIN.
The light bands contain actin and is called isotropic or I-Band. Whereas the dark band called A or Anisotropic band contains myosin. Both the proteins are arranged rod like structures parallel to each other and also to the longitudinal axis of the myofibrils, actin filaments are thinner as compared to myosin filaments.
Z line bisects I-band, mmade of elastic fibres and attaches thin filament. Thick filaments are held by M line.
SARCOMERE - functional unit of contraction/portion of myofibril b/w two successive Z line.
Central part of thick filament,not overlapped by thin filament is called the H zone.

NEET 2013
AIPMT 2001

STRUCTURE OF CONTRACTILE PROTEINS

Each actin (thin) filament is made of two F (filamentous) actins helically wound to each other. Each F actin is a polymer of monomeric G (globular) actins. Two filaments of another protein, tropomyosin also run close to F actins throughout its length. A complex protein troponin is distributed at regular intervals on the tropomyosin in resting state a subunit of troponin masks the active site for myosin on the actin filaments.
Each myosin (thick) filament is polymerised protein of monomers as meromyosin (cone thick filament)
Meromyosin ——> tail (light meromyosin) + short arm + globular head (heavy meromyosin)
The head and short arm projects outward at regular distance and angle from each other from the surface of a polymerised myosin filament and is known as cross arm.
Globular head has active site for ATP, Active ATP'ase enzyme and actin.

AIPMT 2006

MECHANISM OF MUSCLE CONTRACTION

(Sliding filament theory)

> sliding of thin filaments over thick filaments.
> muscle contraction is initiated by signal sent by CNS.
> the junction b/w a motor neuron and & sarcolemma is called neuromuscular junction or motor end plate.
> neural signal releases acetylcholine
> action potential is generated in sarcolemma.
> it spreads through the muscle fibre & causes release of Ca2+ in the sarcoplasm.
> Ca2+ binds with troponin unmasking the binding site.
> using ATP myosin head binds to exposed active sites on actin to form cross bridge.
> z line are pulled inverts (shortening of sarcomere) i.e. contraction (A band are as it is only I band come closer)
> new ATP binds and cross bridge is broken and the cycle continues till Ca2+ are pumped back to sarcoplasmic reticulum.
> masking again takes place, Z lines return to their position i.e. relaxation.
Repeated activation of muscle may lead to formation of lactic acid because of anaerobic break down of glycogen causing fatigue.

MUSCLES

Red fibres
> myoglobin (red coloured O2 storing pigment) content is high
> more amt. of mitochondria
> use O2 for ATP production
> aerobic muscles

White fibres
> myoglobin content is less
> less amt. of mitochondria
> do not use O2 for ATP production
> Amt. of sarcoplasmic reticulum is high

SKELETAL SYSTEM

Bones have hard matrix due to Ca salts & cartilage have slightly pliable matrix due to chondritin salts.
Total 206 bones are present in skeletal system

AXIAL SKELETON (80 bones)
> 80 bones distributed along the main axis.
> skull + vertebral column + sternum + ribs

APPENDICULAR SKELETON (126 Bones)
> bones of limbs along with their girdles constitute the appendicular skeleton.
> each limb have 30 bones

Points regarding skeletal system

> SKULL(22 bones) = 8 Cranial bones + 14 facial bones
> single U shaped bone called hyoid is present at the base of buccal cavity. (Included in skull)
> each middle ear contains 3 tiny bones - Malleus incus and stapes (smallest) collectively called ear ossicles.
> the skull articulates with superior region of vertebral column with the help of 2 occipital condyles (dicondylic skull)
> vertebral column attaches ribs,supports head, protects spinal cord & musculature.
> our vertebral column is formed by 26 vertebrae (dorsally placed).
> each vertebra have neural canal (central hollow portion).
> atlas (1st vertebrae) articulates with occipital condyles.
> vertebral column = cervical (7) + thoracic (12) + lumbar (5) + sacral {(5)=1} + coccyx {(4)=1}
> sternum is a flat bone on the ventral midline of thorax.
> 12 pair of ribs dorsally connected to vertebrae and ventrally to sternum
(Hence it is known as bicephalic) → connected via hyaline cartilage AIPMT 2000
> 12 pair of ribs = 7 true ribs + 3 false ribs (vertebrochondral ribs) + 2 floating ribs
> the bones of fore limb are humerus, radius,ulna,8 carpals(wrist bones),5 metacarpals(palm bones), 14 phalanges (digits)
> bones of hind limb are femur (longest),tibia,fibula,7 tarsals (ankle bone),5 metatarsals,14 phalanges,1 cup shaped patella over knee (knee cap)
> pectoral and pelvic girdle bones help in articulation of the upper and lower limbs respectively with axial skeleton.
> each girdle is formed of 2 halves. AIPMT 2005
> each half of pectoral girdle include clavicle(collar bone with 2 curvature)& scapula (triangular shaped dorsal flat bone present b/w 2nd & 7th rib).
> the scapula has slightly elevated ridge called spine which forms acromion process (clavicle articulates with it). Below acromion a depression glenoid cavity is present which articulates with the head of humerus to form shoulder joint.
> pelvic girdle is formed of 2 coxal bones each is formed of 3 bones (ilium,pubis,ischium). At the point of fusion a cavity acetabulum to which thigh bone articulates. 2 halves meef to form pubic symphysis (help in parturation) ventrally containing fibrous cartilage.

JOINTS

Force generated by muscles is used ti carry movements through joints where joint act as fulcrum.

Fibrous joints
Do not allow any movement.
Eg- sutures connected with fibrous connective tissue.
(Flat skull bone) AIPMT10, 15

Cartilaginous joints
Eg- joint b/w adjacent vertebrae (permits little movement)

Synovial joints
Characterised by fluid filled synovial cavity b/w bones.
These joints helps in locomotion

- **BALL AND SOCKET JOINT** — Eg- b/w humerus & pectoral girdle
- **HINGE JOINT** — Eg- knee joint — AIPMT 2009
- **PIVOT JOINT** — Eg- b/w atlas & axis — NEET 2017
- **GLIDING JOINT** — Eg- b/w carpals
- **SADDLE JOINT** — Eg- b/w carpal and metacarpal of thumb

DISORDERS OF MUSCULAR AND SKELETAL SYSTEM

1) **MYASTHENIA GRAVIS** - auto immune disorder affecting neuromuscular junction leading to fatigue (weakening & paralysis of skeletal muscle)
2) **MUSCULAR DYSTROPHY**- degeneration of skeletal muscle due to gene disorder NEET 2019
3) **TETANI** - less Ca2+ in body fluid hence rapid spasms (wild contraction)
4) **ARTHRITIS** - inflammation of joints
5) **OSTEOPOROSIS** - (age related disorder) decrease in bone mass and increase in bone fractures because of decreased estrogen. Neet2016
6) **GOUT** - inflammation of joints due to accumulation of uric acid crystals. Neet 2013

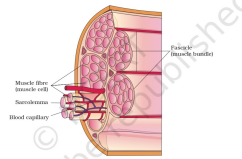


Figure 20.1 Diagrammatic cross sectional view of a muscle showing muscle bundles and muscle fibres

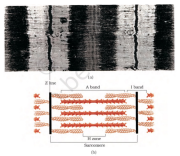


Figure 20.2 Diagrammatic representation of (a) anatomy of a muscle fibre showing a sarcomere (b) a sarcomere

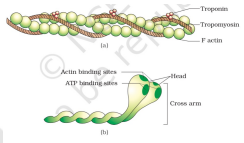


Figure 20.3 (a) An actin (thin) filament (b) Myosin monomer (Meromyosin)

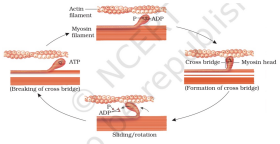


Figure 20.4 Stages in cross bridge formation, rotation of head and breaking of cross bridge

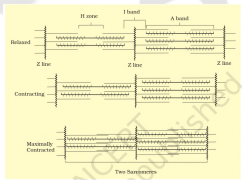


Figure 20.5 Sliding filament theory of muscle contraction Movement of the thin filaments and the relative size of the I band and H zones

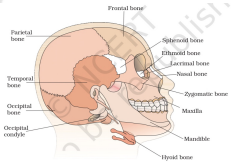


Figure 20.6 Diagrammatic view of human skull

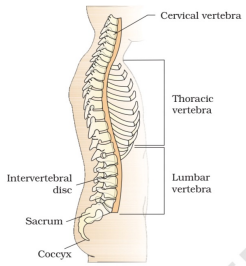


Figure 20.7 Vertebral column (right lateral view)

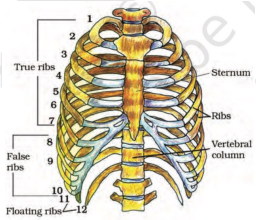


Figure 20.8 Ribs and rib cage

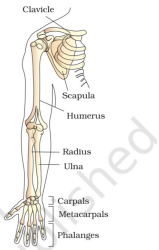


Figure 20.9 Right pectoral girdle and upper arm. (frontal view)

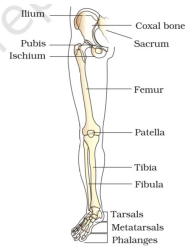


Figure 20.10 Right pelvic girdle and lower limb bones (frontal view)

Neural control and coordination

Coordination is the process through which two or more organs interact and complement the functions of one another. All the organs must work in synchronised fashion under neural & endocrine system.
Neural system provides point to point connections for a quick coordination.

NEURAL SYSTEM

It is composed of neurons which can detect, receive & transmit different kinds of stimuli. In hydra it is composed of a network of neurons in insects a brain is present along with a no. Of ganglia & neural tissues.

CENTRAL NERVOUS SYSTEM

Brain & spinal cord which involve information processing and control.

PERIPHERAL NERVOUS SYSTEM

Nerves of body associated with CNS i.e. afferent fibres (tissue to CNS) and efferent fibres (CNS to tissue).

Visceral nervous system

Include complexes of nerve fibres ganglia or plexus relating with viscera & CNS.

Somatic nervous system

Relays impulse from CNS to skeletal muscle

Autonomous nervous system

Transmits impulse from CNS to the involuntary organs & smooth muscles

- Sympathetic nerve fibres
- Parasympathetic nerve fibres

They work antagonist

NEURON

> Structural and functional unit of neural system
> composed of 3 parts - cell body, dendrites, axon. Dendrites contain nissils granules (modification of endoplasmic reticulum). Neet 2018
> each branch of axon terminates into synaptic knob (bulb like) which possess synaptic vesicles containing neurotransmitter.

They can be of 3 types on the basis of no. Of dendrites:- MULTIPOLAR (1 axon + many dendrites & found in cerebral cortex) or BIPOLAR (1axon + 1 dendrite and found in retina of eye) or UNIPOLAR (only axon and found in embryonic stage.

Neuron can be of 2 types on the basis of presence or absence of mylein sheath.

MYELINATED:- enveloped by shwann cells which produce myelin sheath. They are found in spinal and cranial nerves. They transfer the signal more faster. Neet 2017

NON-MYELINATED:- enveloped by shwann cells which do not produce myelin sheath. They are found in autonomous and somatic neural system.

Gaps b/w two adjacent myelin sheath is known as node of ranvier.

GENERATION AND CONDUCTION OF NERVE IMPULSE

Their membranes are in a polarised state. The ion channels are selectively permeable to diff. ions. When the neuron is resting the axonemal memb. Is more permeable to K+ & impermeable to Na+. Hence the membrane is impermeable to negative charged proteins present in axoplasm. The axon contains more K+ conc. & -vely charged proteins & less Na+ conc. The fluid outside contain less K+ & more Na+. Hence a conc. Gradient is formed which is maintained by active pump which transports 3Na+ outward & 2K+ inward. Hence outer membrane becomes +ve and inner -ve. The electric potential difference across the resting plasma memb. is known as resting potential. When a stimulus is applied the membrane becomes freely permeable to Na+ hence polarity is reversed. Hence the membrane gets depolarised & electric potential difference at that site is called action potential which is termed as a nerve impulse at the inner site the impulse flows from A to B. i.e. from + to - and from outer side B to A i.e. from + to -.

AIPMT 2011

Transmission of impulse

A synapse is formed by the membranes of a presynaptic neuron & a postsynaptic neuron which may or may not be separated by a gap called synaptic cleft.

Synapse is of two types

ELECTRICAL SYNAPSE

> the synaptic cleft is very small
> directly can flow from 1 neuron into the other across this synapse
> it is so similar to impulse conduction in axon
> it is faster than chemical synapse
> they are rare in our system

CHEMICAL SYNAPSE

> pre & post synaptic neurons are separated by fluid filled space called synaptic cleft.
> neurotransmitter are used (Acetylcholine or adrenaline) Neet 2017
> telodendron contain vesicle filled with neurotransmitter
> during the passage of impulse vesicle fuse with the memb. and release the chemicals in cleft. The chemicals bind to their specific receptors this opens ion channels which generate new potential in postsynaptic neuron. The new potential generated may be excitatory or inhibitory.

CENTRAL NERVOUS SYSTEM

Brain act as command and control system. The human is well protected by skull, cranial meninges (duramater, arachnoid and piamater)

Forebrain

Consist of cerebrum, thalamus & hypothalamus a deep cleft divides cerebrum into a2 cerebral hemispheres which are interconnected by tract of nerve fibres called corpus callosum. Cerebral cortex are thrown in prominent folds & referred as grey matter because of conc. Of neuron. Cerebral cortex contain motor and sensory areas and largely areas which have neither function which are known as association areas. They are responsible for inter sensory association, memory and communication. Fibres of tract are covered with the myelin sheath. Which constitute the inner part of cerebral hemisphere they give an opaque white appearance to the layer (white matter)

The cerebrum wraps around a structure called thalamus, which is major coordinating centre for sensory & motor signalling. The hypothalamus contains a no. Of centres for thermoregulation, urge for drinking & eating. It have some neurosecretory cells which secrete hypothalamic hormones. Inner parts of cerebral hemispheres consist of associated deep structure like amygdala,hippocampus form limbic system/limbic lobe along with hypothalamus it is involved in regulating sexual behaviour,expression of emotional reactions. (Eg-excitement,pleasure,rage & fear) and motivation.

Neet 2019

Midbrain

Located b/w thalamus/ hypothalamus of forebrain & pons of hind brain. A canal called cerebral aquaduct passes through midbrain. It's dorsal portion consist of 4 round swollen (lobes) called corpora quadrigemina

Brain stem = mid brain + hind brain except cerebellum. Brain stem connects brain to spinal cord.

Hindbrain

PONS- consist of fibre tracts that interconnect different regions of brain.

CEREBELLUM- has very convulated surface in order to provide additional space for many neurons.

MEDULLA- connected to spinal cord, control respiration,cardiovascular reflexes,gastric secretions.

Neet 2018

REFLEX ACTION & REFLEX ARC

The entire process of response to a conscious effort or thought and requires involvement or a part of the CNS is called a reflex action.

Reflex arc:-

EFFECTOR ORGAN ⟵ Afferent (receptor) ⟵ CNS (At the level of spinal cord)

CNS (At the level of spinal cord) ⟵ Efferent (effector) ⟵ EFFECTOR ORGAN

SENSE ORGAN

NOSE:- mucous coated olfactory receptors (made of olfactory epithelium consist of 3 cells). Neurons from surrounding comes to bean sized organ called olfactory bulb (limbic system). Nose & tongue detect dissolved chemical. Gustation and olfactory functions similarly & interrelated.

In tongue we have taste buds in which gustatory receptors are present.

EYE!

> located in sockets of skull (orbits)

> eye ball is spherical in structure which is composed of 3 layers.

> external layer is sclera (composed of dense connective tissue. Its anterior portion is called the cornea

Neet 2019

> middle layer/choroid- bluish in colour (contain many blood vessels) it is thin over the posterior 2/3rd of the eye ball but it becomes thick in anterior part to form ciliary body. Ciliary body continues forward to form a pigmented opaque structure called iris (visible coloured portion of eye).

Neet 2018

> crystalline lens is held by ligaments attached to ciliary body. Pupil is surrounded by iris whose diameter is regulated by the muscle fibres of iris.

> inner layer/retina- contains 3 layers of nerve cell. Outer photoreceptor cells, middle bipolar cells, inner ganglion cells. Photoreceptor cells light sensitive proteins called photopigments.

Neet2017

RODS:- twilight/scotopic vision, contain rhodopsin (purplish-red protein) its also called visual purple and is a derivative of Vit A

CONES:- daylight (photopic) & coloured vision. They are of three types which responds to red,green & blue light. (If stimulated equally then sensation of white light is produced)

Optic nerve leave & retinal b.v. enter it at a point (slightly above the posterior pole of eyeball) where photoreceptor cells are not present i.e. called as blind spot.

Lateral to blind spot a yellow spot is present with greatest visual acuity (resolution) due to dense packing of cones. That point is known as maculae lutea with central pit called fovea.

MECHANISM OF VISION:-

Light generate potential in rods & cones —> photopigments composed of opsin & retinal (aldehyde of vit A) —> dissociation of retinal and change in structure of opsin —> membrane permeability changes & p.d. generated in rods & cones. —> action carried in ganglion cells through bipolar cells —> via optic nerve it travels to visual cortex of brain and nerve impulses are analysed & image is formed on retina which is recognised based on earlier memory.

EAR!

Outer ear

> pinna + external auditory meatus (canal)
> pinna collect sound vibrations.
> meatus Leads vibration upto tympanic membrane(eardrum)
> various hairs,wax secreting substance/ glands are present.
> tympanic membrane = connective tissue + skin outside + mucous membrane inside.

Middle ear

Consist of ear ossicles (malleus incus and stapes) arranged in chain like fashion.
> vibration from eardrum -> malleus -> incus -> stapes -> oval window of cochlea. (Neet2020)
Ear ossicles increase efficiency of transmission of sound waves.
Eustachian tube connects middle ear to pharynx which equalises pressure on either side of ear drum. Neet2020,22

Inner ear

Fluid filled inner ear called labyrinth (bony labyrinth- series of channels & membranous labyrinth- present in that channels)
> membranous labyrinth is filled with fluid called endolymph and is surrounded by fluid called perilymph. Coiled portion of membranous labyrinth is called cochlea.
> cochlea constitutes 2 membranes (reissners and basilar) which divide bony labyrinth (surrounding perilymph filled) unto upper scala vestibuli & lower scala tympani. (Neet 2020,21)
Space within cochlea is known as scala media & fillded with endolymph.
> at the base of cochlea the scala vestibuli ends at the oval window, while scala tympani terminates at round window which opens to the middle ear.

Organ of corti is present on basilar membrane which contain hair cells that act as auditory receptors and are present in rows on the internal side of organ of corti.
Basal end of hair cell is in contact with the afferent nerve fibres & stereocilia are present at its apical part.
Above hair cells, then elastic membrane called tectorial membrane is present.
VESTIBULAR APPARATUS:- present above cochlea & is composed of 3 semicircular canal & otolith (macula is the sensory part of saccule & utricle)
Each semi circular canal lies in a different plane perpendicular to each other. The membranous canals are suspended in the perilymph of the bony canals. The base of canals js swollen and called ampulla which contains a projecting ridge called crista ampullaris which has hair cells. The saccule & utricle contain a projecting ridge called macula (crista & macula are specific receptors of vestibular apparatus responsible for body balance and posture maintenance).

MECHANISM OF HEARING:-
Eardrum vibrates due to sound vibration —> vibration is sent to oval window via ossicles —> vibrations are passed in fluid of cochlea which generate waves in lymph. —> this induce ripple in basilar membrane—> basilar membrane bend hair cells pressing them against tectorial membrane—> nerve impulse is generated in afferent fibres which travel to auditory cortex in brain via auditory nerves —> and thus sound is recognised.

education

NCERT diagrams for reference

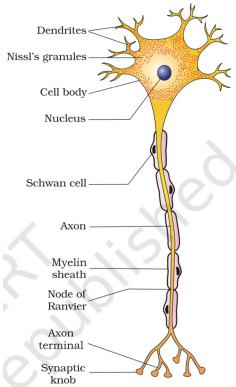


Figure 21.1 Structure of a neuron

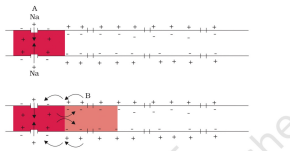


Figure 21.2 Diagrammatic representation of impulse conduction through an axon (at points A and B)

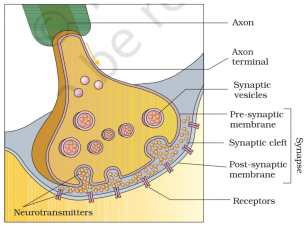


Figure 21.3 Diagram showing axon terminal and synapse

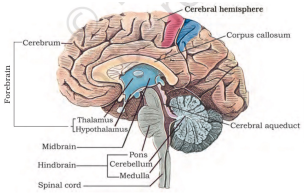


Figure 21.4 Diagram showing sagital section of the human brain

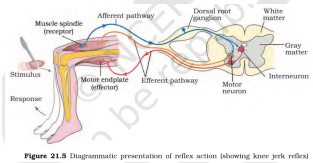


Figure 21.5 Diagrammatic presentation of reflex action (showing knee jerk reflex)

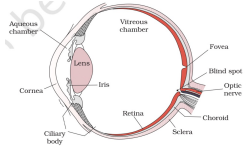


Figure 21.6 Diagram showing parts of an eye

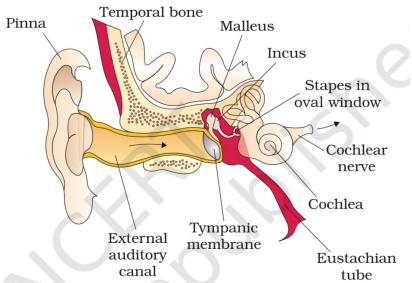


Figure 21.7 Diagrammatic view of ear

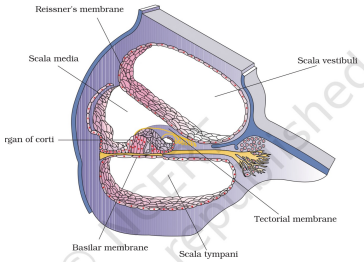


Figure 21.8 Diagrammatic representation of the sectional view of cochlea

Chemical coordination and integration

Needed because neural coordination is short lived.

ENDOCRINE GLANDS & HORMONES:-

Classically hormones are chemicals released by ductless glands. They are non nutrient chemicals which act as intercellular messengers and are produced in trace amounts. Invertebrates have less hormone while vertebrates have more hormonea.

NEET 2013

HUMAN ENDOCRINE SYSTEM

Endocrine glands + hormone secreting cells
It consists of pituitary, pineal, adrenal, pancreas, parathyroid, thymus, gonads, gastrointestinal tract, liver, kidney (JGA), Heart.
Biochemicals released from pituitary causes physiological response dissolved in blood.

The hypothalamus

Basal part of diencephalon fore brain.
It contains neurosecretory cells (group) called nuclei to secrete hormone which regulate the function of pituitary. It secrete 2 type of hormone.
RELEASING HORMONES(RH) - stimulate secretion of pituitary hormone. Eg- gonadotropin Releasing hormone (GnRH) stimulates release of gonadotropin from pituitary.
INHIBITING HORMONE(IH) - inhibit the secretion. Eg- somatostatin inhibits secretion of growth hormone.
Hormone travels via hypothalamic neuron to axon and release after reaching nerve ending.
Hormones regulate anterior pituitary reaching via portal circulatory system and posterior pituitary is under direct neural regulation. It secretes total 14 hormones.

Pineal gland

Present at dorsal side of fore brain, secretes melatonin which regulates 24 hour (circardian rhythm) diurnal rhythm of body. It is directly affected by light. It regulates the sleep wake cycle, temp. , metabolism, pigmentation, menstrual cycle, defence capabilities.

AIPMT 2014

The pituitary gland

Present in bony cavity called sella tursical and attached to hypothalamus by a stalk. It is anatomically divided into:

- ADENOHYPOPHYSIS
  - Pars distalis (Anterior pituitary)
    Secrete:
    > growth hormone (GH)
    > prolactin (PRL)
    > Thyroid stimulating hormone (TSH)
    > Adrenocorticotropic hormone (ACTH)
    > Lutenizing hormone (LH)
    > follicle stimulating hoemone (FSH)
  - Pars intermedia (Merged with distalis)
    Secrete only melanocyte stimulating hormone (MSH)
- NEUROHYPOPHYSIS/ pars nervosa/ posterior pituitary
  Stores and release oxytocin & vasopressin (released by hypothalamus via axonally to it) Neet 2016

Increased secretion of GH causes Gigantism, and less secretion causes dwarfism. If there is increased secretion of GH In middle age then disfigurement in face (acromegaly) which may lead to premature death which is not detected in earlu stages until changes in external features occurs. (NEET 2019

Prolactin:-growth of mammary gland & formation of milk in them
TSH:- stimulate release of thyroid hormone
ACTH:- synthesis of steroid hormones called glucocorticoids from adrenal cortex.
LH & FSH are the gonadotropins
LH:- stimulate secretion of secretion of androgen from testis in male & induces ovulation of fully mature follicles (Graafian follicle) and maintains corpus luteum formed from remnants of graafian follicle after ovulation.
FSH:- in male it with androgen regulate spermatogenesis & in female it stimulate growth and development of ovarian follicles.
MSH:- acts on melanocytes (melanin containing cells) and regulate pigmentation.
Oxytocin:- stimulate contraction of smooth muscle and in females it contracts uterus at times of childbirth and milk ejection.
Vasopressin:- stimulate reabsorption of water & electrolytes & called anti diuretic hormone (ADH) because it overcomes diuresis (loss of H2O) and its impairment leads ti excessive loss of H2O (dehydration) & leads to diabetes insipidus.

Thyroid gland

2 lobes located on either side of trachea which are interconnected by thin flap of connective tissue called isthmus.
Thyroid = follicles + stromal tissues.
Follicles are formed of follicular cells enclosing a cavity and they secrete two types of hormones, TETRAIODOTHYRONINE/Thyroxine (T4) and TRIIODOTHYRONINE (T3)
>Deficiency of iodine/ hypothyroidism:- enlargement of thyroid/goitre. During pregnancy causes defective development like stunted growth (cretinism,mental retardation, low intelligence quotient, abnormal skin, deaf mutism, etc. In adult women it disturbs menstrual cycle. (Neet 2013 ,21)
>Hyperthyroidism:- because of thyroid cancer or development of nodules in thyroid. Eg- Exopthalmic goitre/ Grave's disease => enlargement of thyroid, protrusion of eyeball, increased rate of metabolism, weight loss. NEET 2020
Thyroid hormones help in formation of RBC & Carbs,protein,fat metabolism. They also maintain H2O electrolyte balance and BMR. The gland secretes a protein hormone called thyrocalcitonin (TCT) which regulate Ca2+ levels in blood.

Parathyroid gland

> in humans there are 4 PTG on back side of thyroid.
> they secrete peptide hormone (parathyroid hormone or PTH) which is regulated by circulating Ca2+ levels in blood.
> PTH increase Ca2+ Level in blood by bone resorption (dissolution/demineralisation) (NEET 2018)
> PTH increase Ca2+ absorption from digested food and reabsorption from renal tubules.
PTH is hypercalcimic hormone and along with TCT it plays a significant role in calcium balance.

Thymus

Lobular(bilobed) structure present b/w lungs behind sternum on ventral side of aorta. Involved in primary immune system (lymphatic system) and secrete thymosins which help in differentiation of T lymphocytes which provide cell mediated immunity. Thymosins also promote production of antibodies to provide the humoral immunity. It degenerate in older humans hence immune system becomes weak.

Pancreas

Composite/heterocrine/mixocrine gland
Endocrine pancreas consists of 1-2 million islets of langerhans representing only 1-2 % of pancreatic tissue.
Islet of langerhans => α cells (secrete glucagon) + β cells (secrete insulin) + δ cells (somatostatin).
GLUCAGON:- peptide hormone, maintain blood sugar level. Acts on hepatocytes and it also stimulate gluconeogenesis which also support to hyperglycemia. It reduces the cellular glucose uptake & utilisation and hence called hyperglycaemic hormone. Prolonged hyperglycaemia causes diabetes mellitus which means loss of glucose through urine & formation of harmful ketone bodies. Thus the victims are treated with insulin therapy.
INSULIN:- peptide hormone, maintain regulation of glucose homeostasis. Acts on hepatocytes & adipocytes to enhance cellular glucose level which leads to movement of glucose from blood to cells i.e. Blood sugar level decreases i.e. hypoglycaemia. Insulin stimulates glycogenesis.
Hence glucose level in blood is maintained by both glucagon and insulin.

NEET 2020

Hormones of heart, kidney & gastro-intestinal tract

> Atrial wall of heart secrete atrial natriuretic factor (ANF) which decreases BP by dilating blood vessel. ANF is a peptide hormone.
> Juxtraglomeular cells secrete erythropoietin (peptide hormone) which stimulate erythropoiesis.
> In gastrointestinal tract there are mainly 4 peptide hormones.
GASTRIN:- acts on gastric glands to secrete HCl & pepsinogen
SECRETIN:- acts on exocrine pancreas to secrete H2O & HCO3- ion.
CHOLECYSTOKININ (CCK):- acts on pancreas & gall bladder to secrete pancreatic enzymes & bile.
GASTRIC INHIBITORY PEPTIDE (GIP):- inhibits gastric secretion.
Some other non endocrine tissue secrete hormones called growth factors responsible for normal growth of tissues and their repairing/regeneration.

NEET 2020

Adrenal gland

In pair, present on anterior part of kidney. Its centrally located tissue is called adrenal medulla and outside (periphery) located is called adrenal cortex.
ADDISON'S DISEASE:- underproduction of hormone from adrenal cortex causing weakness, fatigue due to alter in carbs metabolism.
ADRENAL MEDULLA SECRETE:- adrenaline/epinephrine or noradrenaline/ norepinephrine both called catecholamines/ emergency hormones/ hormones of fight or flight.
These hormones increase alertness, pupilary dilation, piloerection (raising of hair), sweating. Both increase heart beat, BP, rate of respiration. They increase blood sugar level by breaking glycogen & lipids & proteins.

3 Layers of adrenal cortex are zona reticularis (inner layer), zona fasciculata (middle layer), zona glomerulosa (outer layer).
Adrenal cortex secrete various corticoids hormones:-
GLUCOCORTICOIDS:- involved in glucose metabolism. Eg- cortisol in our body which also maintains cardiovascular system and kidney functions. They stimulate gluconeogenesis, lipolysis, proteolysis & inhibit cellular uptake and utilisation of amino acids. Cortisol produce anti inflammatory reactions & suppress immune response & also stimulate RBC production.
MINERALOCORTICOIDS:- regulate balance of H2O & electrolyte in body. Eg- aldosterone which acts at renal tubules & allows reabsorption of Na+ & H2O and secretion of K+ & Phosphate. It also maintains osmotic pressure & blood pressure & also maintains electrolyte, body fluid volume.
ANDROGENIC STEROIDS:- play role in growth of axial hair, pubic hair & facial hair during puberty.

Testis

Present in pair in scrotal sac (outside abdomen) & performs as primary sex organs as well as endocrine gland. Testis = seminiferous tubules + stromal/ interstitial tissue + leydig cells/interstitial cells (present in intertubular space & secrete androgens mainly testosterone). (NEET2018)
Androgen regulate function of accessory sex organs like epididymis, vas deferens, seminal vesicles, prostate gland, urethra & sec. sexual character in male and also stimulate spermatogenesis (formation of spermatozoa) and also affect CNS & influence male sexual behaviour (libio). These hormones anabolic effects on protein & carbs metabolism.

Ovary

Pair of ovary in abdomen and produces 1 ovum during each menstrual cycle. It produces 2 groups of steroid hormones estrogen and progesterone.
Ovary = ovarian follicles(secrete estrogen) + stromal tissues
After ovulation ruptured follicle is converted to corpus luteum which secrete progesterone. (NEET2017)
ESTROGEN:- produce sec. sexual character in female, development of ovarian follicles, mammary gland development, female sexual behaviour.
PROGESTERONE:- supports pregnancy, acts on mammary gland to form alveoli (sac structure to store milk) & milk secretion.

Mechanism of hormone action

Hormone bind with hormone receptors located on the cell membrane of target cell and also intracellular receptors (mostly nuclear receptors). Hormone receptor complex is formed. Each receptor is specific to 1 hormone only. Biochemical changes occur in target tissue i.e. took over metabolism & physiological function.
TYPES OF HORMONES ON THE BASIS OF CHEMICAL NATURE:-
1)PEPTIDE,POLYPEPTIDE,PROTEIN HORMONES- insulin,glucagon,pituitary, hypothalamic hormones.
2) STEROIDS- cortisol, testosterone, estradiol, progesterone
3) IODOTHYRONINES- thyroid hormones.
4) AMINO-ACID DERIVATIVES- epinephrine → NEET 2018
Hormones which interact with membra bound receptors normally do not enter cell but generate second messengers. Eg- normally do not enter cell but generate second messenger (Eg- cyclic AMP,IP3,Ca2+) which further regulates metabolism.
Hormones which interact with intracellular receptors (eg- steroids,iodothyronines) mostly regulate gene expression or chromosome function by the interaction of hormone receptor complex with the genome. Cumulative biochemical actions result in physiological & developmental effects.

AIPMT 2016
NEET 2019

NCERT diagrams for reference

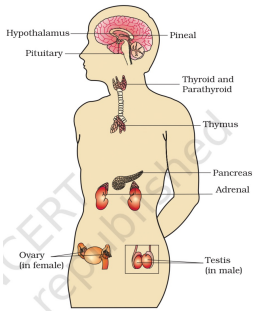


Figure 22.1 Location of endocrine glands

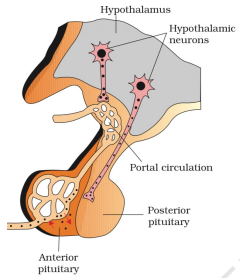


Figure 22.2 Diagrammatic representation of pituitary and its relationship with hypothalamus

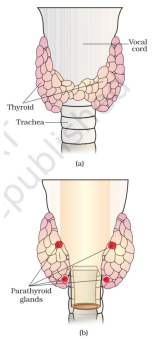


Figure 22.3 Diagrammatic view of the position of Thyroid and Parathyroid
(a) Ventral side
(b) Dorsal side

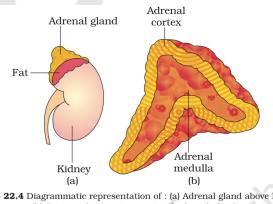


Figure 22.4 Diagrammatic representation of : (a) Adrenal gland above kidney (b) Section showing two parts of adrenal gland

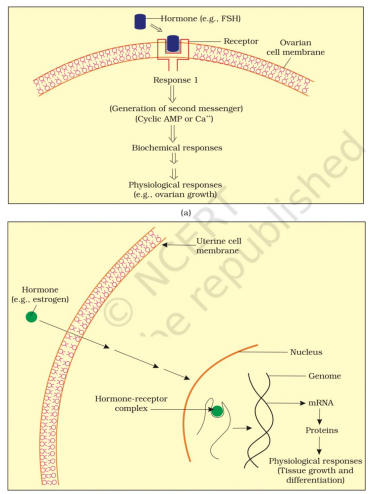


Figure 22.5 Diagramatic representation of the mechanism of hormone action :
(a) Protein hormone (b) Steroid hormone